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TWENTY-FIFTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.,

BEING PART III. OF THE FIFTIETH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1913.

ENDING THE THIRTIETH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
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APPROVED BY

THE STATE BOARD OF PUBLICATION.

TWENTY-FIFTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTIETH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

AUG 20 1913

INTRODUCTION.

In accordance with the provision of the act of the Legislature relative to the publication of the reports of the Massachusetts Agricultural College, the report of the experiment station, which is a department of the college, is presented in two parts. Part I. contains the formal reports of the director, treasurer and heads of departments, and papers of a technical character giving results of research work carried on in the station. This will be sent to agricultural colleges and experiment stations and to workers in these institutions as well as to libraries. Part I. will be published also in connection with the report of the Secretary of the State Board of Agriculture, and will reach the general public through that channel. Part II. will contain papers of a popular character, and will be sent to all those on our general mailing list, as well as to agricultural colleges and experiment stations, to workers in these institutions and to libraries in Massachusetts.

FRED W. MORSE,
Acting Director.

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MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-FIFTH ANNUAL REPORT

Part I.

ORGANIZATION.

Committee on Experiment Department.

Charles H. Preston, *Chairman.*
J. Lewis Ellsworth.
Arthur G. Pollard.
Charles E. Ward.
Harold L. Frost.

The President of the College, *ex officio.*
The Director of the Station, *ex officio.*

Station Staff.

William P. Brooks, Ph.D., *Director.*[1]
Fred W. Morse, M.Sc., *Acting Director.*
Joseph B. Lindsey, Ph.D., *Vice-Director.*
Fred C. Kenney, *Treasurer.*

Department of Plant and Animal Chemistry.

Joseph B. Lindsey, Ph.D., *Chemist.*
Edward B. Holland, M.Sc., *Associate Chemist, in charge of Research Division.*
Fred W. Morse, M.Sc., *Research Chemist.*
Henri D. Haskins, B.Sc., *In charge of Fertilizer Section.*
Philip H. Smith, M.Sc., *In charge of Feed and Dairy Section.*
Lewell S. Walker, B.Sc., *Assistant.*
James C. Reed, B.Sc., *Assistant.*
Rudolph W. Ruprecht, B.Sc., *Assistant.*
George R. Pierce, B.Sc., *Assistant.*[2]
Carleton P. Jones, B.Sc., *Assistant.*
Carlos L. Beals, B.Sc., *Assistant.*
James T. Howard, *Collector.*
Harry J. Allen, *Laboratory Assistant.*
James R. Alcock, *Assistant in Animal Nutrition.*

---

[1] On leave. [2] Resigned.

Department of Agriculture.

William P. Brooks, Ph.D., *Agriculturist.*[1]
H. J. Franklin, Ph.D., *In charge of Cranberry Investigations, Wareham.*
Edwin F. Gaskill, B.Sc., *Assistant.*

Department of Horticulture.

Frank A. Waugh, M.Sc., *Horticulturist.*
Fred C. Sears, M.Sc., *Pomologist.*
Jacob K. Shaw, Ph.D., *Research Assistant.*
Howard A. Turner, B.Sc., *Graduate Assistant.*[2]

Department of Vegetable Physiology and Pathology.

George E. Stone, Ph.D., *Vegetable Physiologist and Pathologist.*
George H. Chapman, M.Sc., *Research Assistant.*
Edward A. Larrabee, B.Sc., *Assistant.*

Department of Entomology.

Henry T. Fernald, Ph.D., *Entomologist.*
Burton N. Gates, Ph.D., *Apiarist.*
Arthur I. Bourne, B.A., *Assistant.*

Department of Veterinary Science.

James B. Paige, B.Sc., D.V.S., *Veterinarian.*

Department of Meteorology.

John E. Ostrander, A.M., C.E., *Meteorologist.*
H. W. Angier, *Observer.*

Other Officers of the Experiment Station.

Charles R. Green, B.Agr., *Librarian.*
Herbert J. Baker, B.Sc., *Secretary to the Director.*[2]
Benjamin G. Southwick, B.Sc., *Secretary to the Director.*[2]
Mrs. Lucia G. Church, *Stenographer to the Director.*
Miss Alice M. Howard, *Stenographer, Department Plant and Animal Chemistry.*
Miss F. Ethel Felton, *Stenographer, Department Plant and Animal Chemistry.*
Miss Lina Fisher, *Stenographer, Department Plant and Animal Chemistry.*
Miss Jessie V. Crocker, *Stenographer, Department of Vegetable Physiology and Pathology.*
Miss Bridie E. O'Donnell, *Stenographer, Department of Entomology.*
Miss Grace E. Gallond, *Stenographer, Department of Agriculture.*

---

[1] On leave. [2] Resigned.

PUBLICATIONS DURING 1912.

Annual Report.

Twenty-Fourth Annual Report, Part I., 287 pages; Part II., 90 pages.

Separata from Annual Report.

Report of Entomologist, 8 pages.
Insects of the Year 1911, 4 pages.
Report of the Botanist, 108 pages.
Chemistry of Arsenical Insecticides, 36 pages.
Cranberry Substation, 12 pages.
Heredity, Correlation and Variation in Garden Peas, 22 pages.

Bulletins.

No. 140. Inspection of Commercial Fertilizers, by H. D. Haskins, L. S. Walker, J. F. Merrill and R. W. Ruprecht, 86 pages.
No. 141. The Microscopic Identification of Cattle Foods, by G. H. Chapman, 71 pages.
No. 142. Inspection of Commercial Feed Stuffs, by P. H. Smith, G. R. Pierce and R. W. Ruprecht, 48 pages.

Circulars.

No. 32. An Act to regulate the Sale of Commercial Fertilizers, 4 pages.
No. 33. An Act to regulate the Use of Utensils for testing the Composition or Value of Milk and Cream, 11 pages.
No. 34. An Act to regulate the Sale and Analysis of Food Stuffs used for Live Stock and Poultry, 7 pages.
No. 22. (Reprint) Poultry Manures, their Use and Treatment, 4 pages.
Meteorological Bulletins, 12 numbers, 4 pages each.

REPORT OF THE TREASURER.

ANNUAL REPORT

OF FRED C. KENNEY, TREASURER OF THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1912.

United States Appropriations, 1911–12.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1912, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund), . . .	$15,000 00	$15,000 00
Cr.		
By salaries, ...	$8,908 04	$12,650 33
labor, ...	2,568 46	836 74
publications, ...	261 38	–
postage and stationery, ...	375 76	53 47
freight and express, ...	119 60	22 82
heat, light, water and power, ...	91 68	71 76
chemicals and laboratory supplies, . .	111 11	167 75
seeds, plants and sundry supplies, . .	661 28	223 57
fertilizers, ...	439 80	71 25
feeding stuffs, ...	689 43	–
library, ...	91 08	2 00
tools, machinery and appliances, . . .	30	8 40
furniture and fixtures, ...	164 37	417 70
scientific apparatus and specimens, . .	297 90	308 68
live stock, ...	26 00	–
traveling expenses, ...	129 75	24 95
contingent expenses, ...	15 00	–
buildings and land, ...	49 06	140 58
Total, ...	$15,000 00	$15,000 00

State Appropriation, 1911-12.

Cash balance brought forward from last fiscal year,	$886 90	
Cash received from State Treasurer,	16,875 00	
fertilizer fees,	10,277 00	
farm products,	6,613 10	
miscellaneous sources,	8,143 69	
		$42,795 69
Cash paid for salaries,	$15,024 62	
labor,	8,909 03	
publications,	1,387 85	
postage and stationery,	1,004 80	
freight and express,	166 67	
heat, light, water and power,	252 91	
chemicals and laboratory supplies,	772 41	
seeds, plants and sundry supplies,	1,736 42	
fertilizers,	504 16	
feeding stuffs,	1,142 96	
library,	260 56	
tools, machinery and appliances,	274 79	
furniture and fixtures,	316 04	
scientific apparatus and specimens,	378 87	
live stock,	5 00	
traveling expenses,	2,785 85	
contingent expenses,	190 00	
buildings and land,	895 47	
balance,	6.787 28	
		$42,795 69

REPORT OF THE DIRECTOR.

FRED W. MORSE, ACTING DIRECTOR.

The Agricultural Experiment Station has been unfortunate in the loss of the services of its director during the latter part of the year. Dr. Brooks was obliged to relinquish his work on account of ill health, and accept a leave of absence beginning July 1.

Vice-Director J. B. Lindsey, who acted by appointment from July 1 to October 1, found his duties as chief of the division of chemistry, in both college and experiment station, too arduous and exacting to be combined with those of the director. The trustees accordingly appointed Fred W. Morse acting director on October 1.

There have been several changes among the junior members of the station staff. Mr. Herbert J. Baker resigned his position as secretary to the director on July 1, and accepted a position with the office of farm management in the United States Department of Agriculture. He was succeeded in the experiment station by Mr. Benjamin G. Southwick, but just at the end of the year Mr. Southwick resigned to take a more responsible position in practical agriculture, and the position will remain unfilled until the return of the director.

In the department of plant and animal chemistry, Mr. George R. Pierce, Mr. Carleton P. Jones and Mr. Carlos L. Beals were appointed assistants, the first-named in the feed and dairy section and the others in the fertilizer section. Mr. Pierce resigned at the end of the year, to go to Cuba, where he is employed in a sugar-house. Miss Lina Fisher has been employed in conjunction with the college, to serve for half of the time as stenographer in the feed and dairy section.

In the horticultural department, Mr. Howard A. Turner was appointed July 1 to the position of graduate assistant in plant-breeding, but soon resigned to accept a position with the office of farm management, and the former position has remained vacant.

Miss Grace E. Gallond has been appointed stenographer in the department of agriculture and Mr. H. W. Angier has succeeded Mr. R. W. Hallowell as observer in the meteorological department. Just before the close of the year, Mr. H. D. Goodale of the Carnegie Laboratory, at Cold Spring Harbor, N. Y., was appointed research biologist in poultry-husbandry, to begin work on Feb. 1, 1913.

At the last session of the Legislature the annual appropriation for the maintenance of the experiment station was increased from $10,500 to $15,000, to become available at the beginning of the new fiscal year, Dec. 1, 1913. The trustees have assigned nearly the whole increase to the department of poultry-husbandry, and Prof. John C. Graham has been appointed head of the department, without salary from the experiment station.

The growth of the experiment station has developed a need of more land, and the trustees have deemed it the wiser policy to meet these needs by leasing satisfactory tracts in the vicinity. Two tracts have accordingly been leased, viz., a lot of twenty acres from Mrs. Mary E. Tuxbury for orchard experiments, and a tract of two acres from Mrs. Winifred Tripp for a fertilizer experiment with basic slag phosphate.

The work of the experiment station has continued without interruption along the lines described in the last annual report, and no new investigations have been undertaken; but plans have been adopted for experiments in breeding poultry with the aid of the additional State funds. The details of the progress in the different investigations will be found in succeeding pages reported by the officers who have been respectively intrusted with them.

The asparagus field at the Concord asparagus substation has produced its fourth crop this year. Mr. C. W. Prescott, in charge of the substation, reported an excellent yield amounting to a gross weight of 11,141 pounds of shoots for the whole area of two acres.

The fertilizer experiments on asparagus so far have shown positively that the use of chemical fertilizers alone has maintained the plots so treated at a somewhat higher productiveness than the combination of chemicals with stable manure. There is some indication, however, that the combined treatment will be superior in the years to come.

The three crops preceding this year showed that the maximum yield of asparagus shoots had been reached only with the maximum application of phosphoric acid. The asparagus plant is not at any stage a heavy consumer of phosphoric acid, and there had been applied a calculated surplus of the substance in the minimum amount. Nevertheless, there was evidently a need of more phosphoric acid, so the quantities applied this year were doubled and will be maintained at the higher rate in the years to come.

By another year, with the return to duty of Director Brooks, it will be possible to publish a detailed report of the fertilizer experiments.

Prof. J. B. Norton of the Bureau of Plant Industry, United States Department of Agriculture, has published the results of the experiments in breeding rust-resistant varieties of asparagus in Bulletin 263, Bureau of Plant Industry, entitled, "Methods used in breeding Asparagus for Rust Resistance." The bulletin covers the work up to the end of 1911, and shows notable progress in developing an immune variety. As a result of his field observations, Professor Norton, on page 59, makes the following important statement: "When rust was found in a commercial field, by following it up to the northwest, in the direction from which the prevailing winds come, a young bed, an old neglected bed, or wild asparagus was found in every case, and always with the remains of cluster-cup infections." He then suggests that wild plants should be dug up and burned, new beds should be planted where they will not affect cutting beds, and every shoot in the commercial field should be cut until the middle of June.

The cranberry substation at East Wareham has illustrated one of the uncertainties which confront the cranberry grower. The crop this year when picked was estimated to be a little over

200 barrels, while the crop of 1911 was 850 barrels. Last year's crop returned a gross income of $4,988.33; but this year's crop is not expected to return over $1,100.[1] This low yield was apparently due to a reaction or rest following the exceptionally heavy crop of 1911, because there was a relatively light bloom and no severe injury from insects or disease.

The expenditures at the substation have been grouped under three heads and do not include the salary of the superintendent. They were as follows: —

Expenses of maintenance,	$1,434 62
Permanent improvements,	551 09
Experimental,	1,243 25
Total,	$3,228 96

The work during the coming year will be somewhat curtailed to keep within the decreased income due to the scanty crop of this year. The bog is not expected to be self-sustaining as an experiment station, but as on any commercial bog the work will necessarily be contracted or expanded somewhat in proportion to the funds arising from its produce. The bog is in excellent condition and expenditures for maintenance and improvements can be lessened with no injury to it, while the experimental work can be continued without interruption.

The detailed report of Dr. H. J. Franklin for the past year will be found in another portion of this report. ✓

The Agricultural Experiment Station has completed its thirtieth year. Its record of service can be found in the thousands of pages of its annual reports, bulletins and circulars, to which should be added the personal letters, by tens of thousands, that have been written for individual seekers after information.

During this period three decennial censuses have been taken by the State, viz., 1885, 1895 and 1905. The progress in Massachusetts agriculture shown by these censuses is interesting and indeed striking.

---

[1] The final sales in February, 1913, resulted in a return of $1,082.77 for 190 barrels of screened fruit.

Capital invested in agriculture in 1885 was $216,230,550, and in 1905 it had increased to $288,153,654, or a gain of 33 per cent. The value of agricultural products in 1885 was $47,756,000, and in 1905 it was $73,110,000, a gain of 53 per cent.

The experiment station has borne its part in this progressive agricultural movement and at slight cost to the State. Its average annual income during this period, including funds from the national treasury, has been less than one-fifth of a mill for each dollar invested in agriculture in 1885.

We believe it to be our duty at this time to point out to the people of Massachusetts new ways in which the experiment station can serve them in the years to come. Since the close of the year there have been prepared and brought together from all the departments detailed plans for projects which show new lines of investigation needed for the further advancement of agricultural interests. These projects may be grouped for convenience under the heads of crop production, crop protection, animal husbandry and agricultural economics.

Under crop production there have been proposed plans for systematic plant-breeding, which shall on the one hand determine the fundamental principles underlying the development of new varieties, and on the other hand shall result in the selection and introduction of new strains or varieties of staple farm and garden crops especially suited to our climate and soil. In fruit growing there is pointed out the need of more knowledge of cultural requirements in orcharding, owing to the differences in slope and surface of our hillsides, some of which are steep and some rolling, some rocky and some free from rocks. The adaptability of varieties needs consideration, and its study will require a knowledge of weather conditions and soil formation. A little less than one-fifth of the State has been surveyed by the Bureau of Soils of the United States Department of Agriculture, and it is desirable that this soil survey should be made complete, which must be done at the expense of the State. Judging from the surveys already made in this State and in adjacent States, there are probably between fifty and sixty distinct types of soils composing our farm lands. As specialization in crops increases, it is important that the distribution of these types be known, because it will save many would-be growers of onions, tobacco, asparagus and similar specialties from disappointment and financial loss. New crops for florists need investigation and development, and a more efficient use of fertilizers should be worked out.

Crop protection involves continual study of predaceous insects, destructive fungi and bacteria, and also diseases produced by injudicious cultural methods, particularly in the forced crops under glass. First one insect and then another upsets nature's checks and balances owing to concentration of special crops, and the same thing is true of fungous growths. Instead of new lines of investigation this field requires more workers and more facilities.

In animal husbandry, the new projects may be considered as the expansion of present lines of investigation. The poultry-breeding experiment, which has already been mentioned, is planned to include the selection of a strain of high efficiency as utility fowls, and this project will require a progressive increase of house-room and labor, as the successive generations of fowls are produced. Efficiency in feeding animals is more necessary than ever before; therefore there is positive need for more extensive work in feeding cattle, pigs, horses and poultry than the station now can perform with its facilities. Two phases of the dairy industry, which have been but little studied from a scientific standpoint, are the production of market milk and the manufacture of ice cream. These phases are peculiar to our dense city population adjacent to our farms. Diseases of our domestic animals, particularly of poultry, are becoming of increasing importance due to the enlarged amounts of capital invested in single plants, and calls for diagnosis and advice are almost incessant. The need in all these lines is for more investigators, thoroughly trained specialists, and the demand, the country over, exceeds the supply; therefore the State that bids the highest gets their services.

Economics may not seem a subject belonging to an agricultural experiment station, but certain phases have always been studied. Inspection of fertilizers and feeding stuffs may properly be included under this head, because nothing is of greater importance to the user of capital than the certainty of receiving a full return for its expenditure. There is now needed a thorough investigation of methods of seed-testing and seed-separation as a foundation for a just law controlling the sale of agricultural seeds. Equally important as economic investigations are those of ice-storage of garden vegetables and the utilization of surplus fruit and vegetables in various manufactured products with home or community facilities.

Economical use of our agricultural resources and efficient application of capital to their development require more or less study of State conditions, viz., practices of successful farmers; methods followed in milk-production, potato-growing, corn-growing, fruit-growing and so forth; relation between success and location with respect to local markets, and location with respect to transportation facilities; and the relation between social surroundings and agricultural prosperity.

In planning these projects the station workers have had in mind increasing the service of this institution in behalf of the State for the ultimate development of every farm to a higher state of productivity and the assurance to the farmer of a greater prosperity.

To execute these projects will require double the present income of the experiment station, but the experiment station neither begs nor demands that this income be given it. It has presented the subject to the people and is ready to serve them, and will serve them to the utmost of its facilities.

DEPARTMENT OF AGRICULTURE.

REPORT OF THE AGRICULTURIST.

E. F. GASKILL, ASSISTANT.

The duty of preparing the annual report of the agricultural department has fallen to the assistant agriculturist. Dr. Wm. P. Brooks, who has served as agriculturist of the experiment station since 1889, was forced to give up his duties last June because of ill health, and by vote of the trustees has been given leave of absence until September, 1913.

The work of the department for the past year was outlined almost entirely by Dr. Brooks and has followed the same general lines as in previous years, namely, experiments with fertilizers involving the use of 181 field plots, 13 orchard plots, 132 pots in our vegetation work and 147 inclosed plots, used largely to check results obtained in the field.

From year to year the department has made a careful study of many of the more promising varieties of potatoes, corn and soy beans; has investigated the possibilities of growing alfalfa in the State; and has co-operated with other departments of the station in carrying out many lines of investigation; but the main question under consideration has been the study of problems connected with soil fertility. Preferring to base conclusions on averages for a number of years, rather than on the results for one or two years, many of the fertilizer experiments have been continued from year to year. In view of this fact the report of the experimental work in this department, as in previous years, must in most instances be a report of progress. It is intended to present the work according to the plan generally followed, in order that the successive reports may furnish a complete record of each experiment.

THE COMPARISON OF DIFFERENT MATERIALS AS A SOURCE OF NITROGEN.

Field A.

In this experiment there are eleven plots of one-tenth acre each, separated by division strips 4 feet in width. They have been fertilized each year according to the following plan:[1] —

PLOT.	Source of Nitrogen.	Source of Potash.	Source of Phosphoric Acid.
0	Barnyard manure,[2]	– –	– –
1	Nitrate of soda,	Muriate of potash,	Dissolved bone-black.
2	Nitrate of soda,	Sulfate of potash-magnesia,	Dissolved bone-black.
3	Dried blood,	Muriate of potash,	Dissolved bone-black.
4	Nothing,	Sulfate of potash-magnesia,	Dissolved bone-black.
5	Sulfate of ammonia,	Sulfate of potash-magnesia,	Dissolved bone-black.
6	Sulfate of ammonia,	Muriate of potash,	Dissolved bone-black.
7	Nothing,	Muriate of potash,	Dissolved bone-black.
8	Sulfate of ammonia,	Muriate of potash,	Dissolved bone-black.
9	Nothing,	Muriate of potash,	Dissolved bone-black.
10	Dried blood,	Sulfate of potash-magnesia,	Dissolved bone-black.

The nitrogen, phosphoric acid and potash are applied in equal amounts to all plots except 4, 7 and 9. These receive phosphoric acid and potash but no nitrogen.

During the twenty-three years of the experiment the crops grown have been: 1890, oats; 1891, rye; 1892, soy beans; 1893, oats; 1894, soy beans; 1895, oats; 1896, soy beans; 1897, oats; 1898, oats; 1899, clover; 1900, potatoes; 1901, soy beans; 1902, potatoes; 1903, soy beans; 1904, potatoes; 1905, oats and peas; 1906, corn; 1907, clover; 1908, clover; 1909, clover;

---

[1] The materials are used at the following rates per acre: —

	Pounds.
Nitrate of soda,	290
Sulfate of ammonia,	225
Dried blood,	525
Muriate of potash,	250
Sulfate of potash,	485
Dissolved bone-black,	500
Manure,	8,000

[2] In addition, nitrate of soda, dissolved bone-black and sulfate of potash-magnesia have been applied to equalize the nitrogen, phosphoric acid and potash on plots 1–10.

1910, clover; 1911, corn followed by clover; and 1912, corn followed by clover.

The variety of corn grown this year was the same as last, — Rustler White Dent. It made a very satisfactory growth and was well matured by the 19th of September, on which date it was cut and stooked. The average yields for this year are shown in the following table: —

Average Yields per Acre, 1912.

PLOT.	Hard Corn, Ears (Bushels).	Soft Corn, Ears (Bushels).	Stover (Pounds).
No-nitrogen (4, 7, 9),	67.86	1.61	5,116.70
Nitrate of soda (1, 2),	93.00	1.79	5,700.00
Dried blood (3, 10),	89.57	1.31	5,450.00
Sulfate of ammonia (5, 6, 8),	78.26	1.62	5,133.30
Manure (0),	80.00	1.29	5,000.00

On the basis of 100 for nitrate of soda, the relative standing of the different nitrogen plots and no-nitrogen plots, as measured by total yield during the past season, was as follows: —

	PER CENT.	
	Grain on Cob.	Stover.
Nitrate of soda,	100.00	100.00
Barnyard manure,	94.62	87.72
Dried blood,	96.31	95.61
Sulfate of ammonia,	84.15	90.06
No-nitrogen,	72.97	89.77

The relative standing of the different materials as indicated by total yield for the twenty-three years during which the experiment has continued is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.28
Dried blood,	92.95
Sulfate of ammonia,	87.38
No-nitrogen,	73.04

On the basis of increase as compared with the no-nitrogen plots the relative standing for the different fertilizers for the twenty-three years is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	78.78
Dried blood,	73.85
Sulfate of ammonia,	53.19

Nitrate of soda, as in previous years, shows the greatest average increase. The striking results obtained last year on the no-nitrogen plots are not so apparent this year. In 1911 the yield on the no-nitrogen plots was 95 per cent. of the average yield on all the different nitrogen plots; this year the no-nitrogen plots are represented by 73 per cent. In commenting upon the good showing made by the no-nitrogen plots last year, Dr. Brooks said: —

> One of the most striking results of the past season was the relatively large yield produced on the no-nitrogen plots. It amounts to about 95 per cent. of the average yield on all the different plots which have received an application of nitrogen annually. This result, it will be readily understood, was no doubt due to the fact that clover for three years had preceded the corn crop of the past year. The figures emphasize in a most striking way the extent to which rotations including a legume may be made to take the place of the use of nitrogen fertilizers.

Muriate *v.* Sulfate of Potash.

Field B.

This is the twenty-first year of the experiment. The field consists of five pairs of plots, numbered from eleven to twenty. The odd plots (eleven, thirteen, etc.) have received annually an application of muriate of potash, while the even plots (twelve, fourteen, etc.) have received an application of high-grade sulfate of potash. In addition to the potash the plots have received annually an application of bone meal at the rate of 600 pounds per acre. During the early period of the experiment the potash salts were used in different amounts in different years. For the last twelve years an annual application of

250 pounds per acre has been applied to each plot. The object has been to supply annually the same amount of actual potash to each plot, and to study the effects of the continued use of these potash salts upon the same soil. The following table shows the crops grown this year and the rate of yield per acre for each: —

	Alfalfa (Pounds).	Asparagus (Pounds).	Blackberries (Pounds).	Rhubarb.		Raspberries (Pounds).	Strawberries (Pounds).	Mangel-wurzels.	
				Stalks (Pounds).	Leaves (Pounds).			Roots (Pounds).	Tops (Pounds).
Muriate of potash,	5,837	5,734	4,027	17,647	19,669	939	4,403	40,608	6,486
Sulfate of potash,	7,331	4,348	4,609	25,343	28,302	1,300	5,087	32,897	4,276

Comparison of Different Potash Salts for Field Crops.

Field G.

The plan and object of this experiment is quoted from the nineteenth annual report of the experiment station: —

> This experiment is designed to show the ultimate effect upon the soil, as well as the current effect upon the crops, of continuous use of different potash salts. We have under comparison kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate.[1] The field includes forty plots, in five series of eight plots each. Each series includes a no-potash plot, as well as the seven potash plots which have been named. The experiment is therefore carried out each year in quintuplicate. The area of each plot is one-fortieth of an acre. The potash salts under comparison are used in quantities which will supply annually actual potash at the rate of 165 pounds per acre to each of the plots. All plots are equally manured, and liberally, with materials furnishing nitrogen and phosphoric acid.[2]

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[1] Owing to our inability to obtain silicate of potash feldspar was substituted in 1908, and has since been used on these plots.

[2] The nitrogen and phosphoric acid are supplied by the following materials per acre: —

	Pounds.
Nitrate of soda,	250
Tankage,	270
Acid phosphate,	360

The crops grown on the field this year were as follows: —

Series I., plots 1–8, Rustler White Dent corn.
Series II., plots 9–16, Medium Yellow soy beans.
Series III., plots 17–24, Danish Ballhead cabbage.
Series IV., plots 25–32, Golden Tankard mangel-wurzels.
Series V., plots 33–40, Sweet German turnips.

The relative standing of the different potash salts for this year is shown in the following table: —

Yields per Acre.

POTASH SALT.	SERIES I.			SERIES II.		SERIES III.	SERIES IV.		SERIES V.	
	CORN.			SOY BEANS.			MANGEL-WURZELS.		TURNIPS.	
	Hard Ears (Bushels).	Soft Ears (Bushels).	Stover (Pounds).	Beans (Bushels).	Straw (Pounds).	Cabbage (Pounds).	Roots (Pounds).	Tops (Pounds).	Roots (Pounds).	Tops (Pounds).
No potash,	75.43	-	4,200	24.48	2,920	37,800	31,880	13,720	27,000	13,600
Kainit,	83.43	-	5,600	24.14	2,800	41,000	36,880	16,120	38,520	12,880
High-grade sulfate,	81.14	-	5,280	27.59	3,320	41,400	32,400	12,200	37,120	12,280
Low-grade sulfate,	84.00	-	5,200	28.97	3,520	44,000	38,800	15,200	38,000	11,400
Muriate,	82.86	-	5,400	27.59	3,360	46,880	35,600	14,800	37,400	12,200
Nitrate,	80.57	.57	5,400	28.28	3,500	50,200	28,800	10,200	34,120	10,080
Carbonate,	47.43	1.14	5,480	19.31	2,420	47,400	37,000	12,000	33,400	11,200
Feldspar,	80.57	-	4,200	22.76	2,840	30,600	31,600	13,000	29,800	12,800

Comparison of Different Phosphates.

This is the sixteenth year of the experiment, the plan and object of which is quoted from the twenty-third annual report: —

> Ten of the leading materials which may be used as a source of phosphoric acid have been under comparison in one of our fields since 1897. The different materials are applied to the separate plots in such quantities as to furnish equal amounts of actual phosphoric acid to each. There are three check plots to which no phosphate whatever has been applied during the entire period of the experiment. All the plots receive annually equal and liberal quantities of materials supplying nitrogen and potash in highly available forms. The field has been used for a large variety of crops, the succession having been as follows: corn, cabbages, corn, oats and Hungarian grass (followed by rye plowed under), onions, onions, corn, mixed grass and clover three years, cabbages and soy beans and potatoes.

In view of the fact that the results of similar experiments (comparison of different materials as sources of phosphoric acid) in other States have not shown the marked differences between the ground rock phosphates and the more soluble phosphates that our results show, and in view of the fact that the humus content of the different soils is claimed by some authorities to be the cause of the differences in the showing of the rock phosphates, it has been our aim in the treatment of the field for the last few years to get as much humus into the soil as possible.

In 1911 the field was seeded in May with oats and alfalfa. Two crops were harvested, one in July and one in September. In 1912 the field was plowed and Japanese Buckwheat sown, which was plowed under in July. In August rye was sown, to be plowed under in the spring.

AVERAGE CORN FERTILIZER COMPARED WITH FERTILIZER RICHER IN POTASH.

North Corn Acre.

The two systems of fertilizing have been under comparison for twenty-two years. The object has been to determine whether or not the average corn fertilizer sold on our markets contains the right proportions of nitrogen, phosphoric acid and potash. The field consists of four plots of one-fourth acre each. Two of the plots — 1 and 3 — receive annually an application of a home-made mixture furnishing the different plant-food elements in the same proportions as in average corn fertilizer. The other two plots receive an application of a home-made mixture furnishing less phosphoric acid and more potash than the average corn fertilizer. The rotation is two years of grass and two years of corn. The crop this year was corn. The following table shows the relative standing of the two mixtures for this year: —

	CORN ON THE COB.		Stover (Pounds).
	Hard Ears (Bushels).	Soft Ears (Bushels).	
Average corn fertilizer,	55.66	1.26	3,566
Fertilizer richer in potash,	61.69	1.37	4,090

The different materials were used on the plots at the following rates per acre: —

FERTILIZERS.	Plot 1 (Pounds).	Plot 2 (Pounds).	Plot 3 (Pounds).	Plot 4 (Pounds).
Nitrate of soda,	120	200	120	200
Dried blood,	120	–	120	–
Fish,	150	200	150	200
Acid phosphate,	1,092	200	1,092	200
Muriate of potash,	150	250	150	250
Slag,	–	–	–	400

The amount of plant food furnished an acre, its cost, and the profit realized by using the different mixtures are shown in the following table: —

PLOTS.	Amount (Pounds).	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).	Cost.[1]	Grain (Bushels).[2]	Stover (Pounds).	Value.[3]	Profit.[4]	Formula.
1 and 3, . .	1,632	38.35	196.49	77.68	$17 90	55.66	3,566	$44 97	$27 07	2.35–12.04–4.76
2 and 4, . .	1,050	42.93	104.01	129.63	15 41	61.69	4,090	50 34	34 93	4.09–9.91–12.34
Average corn fertilizer.[5]	1,700	41.65	165.07	76.84	28 27	–	–	–	–	– –

[1] Represents the actual cost of chemicals. To these should be added the cost of mixing, which will range from $1.50 to $2 per ton.

[2] The late spring and the unusually dry summer were not favorable for a good corn crop. In 1911 on these same plots the average yield of the four plots was over 85 bushels per acre.

[3] Based on the value of the crop at harvest time.

[4] Represents the difference between the cost of chemicals and the value of the crop. The labor question was not considered in this comparison because it was the same for all plots.

[5] The prices and formula for the corn fertilizer were obtained by taking an average of all the corn fertilizers reported in the 1911 fertilizer bulletin.

The composition of the corn fertilizers varies widely, and in taking an average of all corn fertilizers, reported in our fertilizer bulletin from year to year, we find considerable variation. The percentage of phosphoric acid is not as high at the present time as in former years.

The tables show that in order to supply about the same amounts of plant food per acre, it would be necessary to use 1,700 pounds of the average corn fertilizer. This at the average price per ton would cost over $28. It will be seen from the figures representing the cost of the different chemical mixtures, and the crops obtained, that it would be necessary to harvest a much larger crop on this fertilizer in order to insure a profit as large as that shown for the other fertilizers.

The prices used in these calculations were as follows: corn on the cob, 60 cents per bushel; stover in the field, $6.50 per ton; fertilizers at the current prices for 1912.

MANURE ALONE COMPARED WITH MANURE AND SULFATE OF POTASH.

South Corn Acre.

The two systems of manuring have been under comparison for twenty-two years. The field consists of four plots of one-fourth acre each. Two of the plots — 1 and 3 — receive an application of barnyard manure at the rate of 6 cords per acre, while the other two receive an application of manure at the rate of 4 cords per acre, and in addition an application of high-grade sulfate of potash at the rate of 160 pounds per acre. The crop grown this year was corn. The relative standing of the two systems for this year is shown in the following table: —

	Corn on the Cob.		Stover (Pounds).
	Hard Ears (Bushels).	Soft Ears (Bushels).	
Manure alone,	67.57	1.43	4,460
Manure and potash,	63.34	1.86	3,840

The following table gives the amount of fertilizer used per acre on each plot, its cost and the profit: —

Plot.	Fertilizer.	Cost.[1]	Grain (Bushels).[2]	Stover (Pounds).	Value.[3]	Profit.[4]
1,	6 cords manure,	$30 00	71.71	4,360	$57 20	$27 20
3,	6 cords manure,	30 00	63.43	4,560	52 88	22 72
2,	4 cords manure and 160 pounds high-grade sulfate.	24 00	60.09	3,800	48 35	24 35
4,	4 cords manure and 160 pounds high-grade sulfate.	24 00	66.63	3,880	52 59	28 59
1 and 3,	Average,	30 00	67.57	4,460	55 01	25 01
2 and 4,	Average,	24 00	63.34	3,840	50 48	26 48

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[1] Represents the actual cost of the fertilizer used.

[2] The late spring and the unusually dry summer were not favorable for a good corn crop. In 1911 on these same plots the average yield of the four plots was over 86 bushels per acre.

[3] Based on the value of the crop at harvest time.

[4] Represents the difference between the cost of the material used and the value of the crop. The cost of spreading the manure was not considered because this item of expense would not be the same in very many cases.

Comparing the average of plots 1 and 3 with the average of plots 2 and 4 we find the materials cost more for 1 and 3; the amount of grain and stover produced is larger, but the profit is less.

The difference in favor of using the smaller amount of manure and potash is still more apparent when we consider that we have two cords less of manure to handle.

Comparison of Winter and Spring Application of Manure.

The details of the plan and object of this experiment may be found in the nineteenth annual report: —

> This experiment was planned to be continued through a series of years, with a view to throwing light upon the question as to the best method of handling farm manures. The field in use has an area of a little less than three acres, and slopes moderately to the west. It had been divided into five plots a number of years previous to the beginning of this experiment, for the comparison of different fertilizers. Each of these five plots was subdivided into two sub-plots. To one of the sub-plots in each of the five pairs the manure is applied during the winter, being spread upon the surface as it is hauled to the field; to the other sub-plot in each of the five pairs the manure as it is hauled is put into a large, compact heap. The manure used is carefully preserved, from well-fed dairy cows on four of the pairs of plots (1, 2, 3 and 4), and purchased stable manure from horses on one pair of plots (5). The experiment is so managed that all the manure is hauled for a single pair of plots at one time, usually during a single day, or at most within two days. To insure even quality of the manure on the two sub-plots, loads are placed alternately on the north half, where it is spread as hauled; and on the south half, where, as has been stated, it is put into a large heap. The land has usually been plowed late in the fall. The manure has usually been applied to the two sub-plots 1 early in the winter; to the sub-plots 2, 3 and 4, respectively, at intervals each about one month later than the preceding. The manure which is placed in the heaps remains there until it is time to prepare the soil for planting in the spring. It is then spread, and as soon as convenient the entire area, including both the winter and spring applications, is plowed.

Manure was omitted in 1912 and will not be applied as in previous years. Records will, however, be kept, the object now being to test the residual effect of the two systems of applying manure. There are five pairs of plots in the experiment. The crop this year was mixed grass and clover hay. The average yields per acre in 1912 were: —

	Hay (Pounds).	Rowen (Pounds).
Winter application,	5,528.4	364.0
Spring application,	5,745.8	795.4

Top-dressing Permanent Mowings.

An outline of the plan and object of this experiment is quoted from the sixteenth annual report: —

> In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about 9 acres. It is divided into three approximately equal plots. The plan is to apply to each plot, one year barnyard manure, the next year wood ashes, and the third year fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds; and muriate of potash, 200 pounds per acre. The manure is always applied in the fall; ashes and the bone and potash in early spring.

The past year brought the fifth successive season unfavorable to hay production. The rain fall in May was slightly above the normal, but the following month was one of the driest Junes recorded since records have been kept here at the college.

The yield obtained this year on the different systems of manuring is shown in the following table: —

Fertilizers used.	Yield per Acre.		
	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure,	3,610	1,359	4,969
Bone and potash,	3,655	1,164	4,819
Wood ashes,[1]	3,171	1,616	4,787

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[1] Owing to the difficulty of securing good wood ashes a mixture of slag and muriate of potash, supplying the same amount of phosphoric acid and potash, was substituted this year.

The average yield for the entire period of the experiment (1893–1912, inclusive) for each system of manuring is shown in the following table: —

	Pounds.
Barnyard manure,	6,149
Bone and potash,	5,999
Wood ashes,[1]	5,636

The average yield for the entire area this year was 4,846 pounds, — a little better than the average yield for last year, but not equal to the average yield for the entire period of the experiment (1893–1912, inclusive) which is 5,959 pounds. The average yield for the period 1893–1911, inclusive, was 6,018 pounds.

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[1] Owing to the difficulty of securing good wood ashes a mixture of slag and muriate of potash, supplying the same amount of phosphoric acid and potash, was substituted this year.

DEPARTMENT OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

REPORT OF THE BOTANIST.

G. E. STONE.

This department has the past year been engaged in the usual routine and research work, investigations being made of the new diseases which come to our attention and which are given a thorough study if they prove serious.

Mr. G. H. Chapman, research assistant, has been engaged on problems of a technical nature, and Mr. E. A. Larrabee's attention has been given mainly to the diagnosis of diseases and seed work. The office work has been carried on as usual by Miss J. V. Crocker, and Mr. R. G. Smith, who is at present assisting in the senior laboratory, performed some experiments in the summer with the chestnut bark disease. Messrs. Torrey, Larsen, Ellis, Lyon, Sullivan and Chase, undergraduate students, have given assistance in various ways, — in the greenhouse, with experiments, etc., and Mr. T. W. Nicolet has taken many of the photographs. A list of several problems which the department has been investigating follows.

A careful study is being made of some of the diseases of field and greenhouse crops. This includes an investigation of the conditions causing the diseases and experiments with methods for their control. Among those receiving special attention are some diseases of the apple, potato, cucumber, melon. lettuce, tomato and herbaceous plants and shade trees. In the last two years there has been present a serious blight on greenhouse cucumbers which has in some instances caused a total failure of the cucumber crop in this section, and some study has been made of this disease. For five years experiments have been carried on relative to the control of potato scab, and some of the results of this work will be contained in this report. These experiments will be continued.

Some further lines of work are given in brief: —

Investigations relating to improved methods of seed germination and separation.

Experiments on the control of weeds in lawns, etc.

Investigations relating to the injurious effects of oil sprays on fruit trees.

Investigations relating to the effects on shade trees of chemical substances applied to roadbeds.

Investigations relating to the effects of different fumigants on greenhouse crops which are subject to variations in light intensity and moisture.

Investigations relating to the effects of various spraying solutions on plants exposed to variations in light intensity, etc.

Investigations relating to the burning of the foliage of greenhouse plants by fumigants as related to the condition of the stomata.

A study of the weed situation in cranberry bogs.

Testing of a large variety of chemical substances to ascertain their fungicidal value.

Investigations relating to overfeeding and malnutrition in greenhouse plants, a trouble which is becoming more common in greenhouses.

Investigations relating to the relationship between various light intensities and the effects of different spraying solutions, and the maximum carbon assimilation in such crops as potatoes, grapes, etc.

Investigations relating to the fixation of nitrogen by the electrical stimulation of micro-organisms.

Experiments with methods of keeping roots from drain tiles, — a continuation of those already published.

A study of spraying machinery and new types of nozzles.

Experiments with a new type of soil sterilizer.

Investigations relating to the mosaic disease as occurring on different plants; nearly completed.

Investigations relating to light in greenhouses; practically completed.

Experiments with methods of treating tree cavities.

Experiments with the effects of varying percentages of soil, moisture and air on the germination of seeds.

Experiments with the effects of ozone on seed germination and various plant activities.

These investigations have been carried on in some cases for some time, and several of them would properly come under the heading, "Investigations of the effects of meteorological conditions on the diseases and the development of plants in general," which we are studying under the "Adams fund."

DISEASES MORE OR LESS COMMON DURING THE YEAR.

G. E. STONE.

Like the year before, this season has been characterized by severe drought in the summer months, with some rain in the fall, although the rainfall in August, September and October was less than the normal. In November, however, it exceeded the normal. In May, June and July the drought and heat were such as to cause considerable defoliation of trees and unevenness in corn fields, although this last was in some cases due to poor seed which was affected by frost the year before.

The unusually large onion crop ripened poorly in some fields, and in the Connecticut valley many hundreds of bushels had to be left on the ground owing to non-maturity. Potatoes were of excellent quality, with less than the usual amount of early blight, and the rot was not very noticeable. Apple trees showed some winter killing of the twigs and roots as the result of the preceding severe winter, with some sunscald and a few cases of what appears to be injury from spraying with oil. The leaves of those trees in particular which were not sprayed were affected to an unusual degree with scab (*Fusicladium*) and leaf spots (*Sphæropsis*). The scab was more or less common on the fruit in the fall and was accompanied in almost every case by pink mold (*Cephalothecium*), but no serious injury occurred. Apple rust (*Gymnosporangium*), which has been more or less common the last three or four years, was seen occasionally on the leaves, and in a few instances affected the fruit. Storage burns were common in some localities, due possibly to defective storage conditions, and in other cases to the rather poor ripening or hardening up of the fruit. Apple fruit rots were unusually abundant late in the fall, being caused, apparently, by the abnormal ripening of the fruit. As usual, there was very little rot (*Glœospo-*

rium) on the tree, but it occurred later at the time of harvesting. The black rot (*Sphæropsis*) usually constitutes 80 or 90 per cent. of our fruit rots, but this year the bitter rot (*Glæosporium*) prevailed and *Sphæropsis* was quite scarce, and for this reason there was more rotting of the fruit on the tree than is usually seen here. The brown rot (*Sclerotinia*) and blue mold rot (*Pencillium*) were quite common, as was the fruit spot (*Cylindrosporium*), which affected many varieties of apples.

Crown gall (*Pseudomonas*) is not so prevalent now as a few years ago, as greater care is being taken in buying apple stock. Peach leaf-curl (*Exoascus*) was unusually severe in the spring, especially on unsprayed trees, and much curling of the foliage was caused by aphis. Peach and plum rots (*Sclerotinia*) were not common, and other than the winter killing of the fruit buds the trees made good growth and were quite free from disease. There was some pear blight (*Bacillus*) and sooty mold, which grows in the secretions of aphis. Rusts (*Gymnosporangium*) in general have been more common the past four years, but they were less conspicuous this season than last. Among these may be mentioned quince, bean, apple, Vinca, rose and ash rust. The quince rust continues to be more or less of a pest. The white pine blister rust (*Cronartium*), introduced a few years ago, is now receiving attention from the nursery inspector. The European currant rust, one stage of the pine blister rust, has recently made its appearance, being first observed on the black currant in Essex County, the only location known in this State at the present time.

Among other more or less common diseases noticed during the year are the maple leaf spot (*Rhytisma*), pea mildew (*Erysiphe*), several sweet pea troubles of a miscellaneous character, the leaf spot of the cherry (*Cylindrosporium*), asparagus rust (*Puccinia*), oat smut (*Ustilago*), hollyhock rust (*Puccinia*), potato scab (*Oospora*), corn smut (*Ustilago*), black rot of grape (*Guignardia*), bacterial wilt of cucumbers (*Bacillus*), currant leaf spot (*Septoria*), frost injury to asparagus, blossom end rot of tomatoes and scab (*Cylindrosporium*), oak and sycamore leaf blight (*Glæosporium*), black spot of rose (*Actinonema*), rose mildew (*Sphærotheca*), leaf spot of mignonette (*Cercospora*), melon blight (*Alternaria*), celery blight (*Cercospora*), apple canker (*Sphæropsis* and *Nectria*), and winter killing of raspberries and roses, sycamore twigs, privet and others.

The unusually severe infection from aphis caused a loss of foliage to many trees. A peculiar mottling of chestnut leaves which were thickly covered with honey-dew was noticed, and examinations of the leaf tissue revealed a partial plasmolysis of the cells, accompanied by considerable defoliation; but after showers, which would wash off the honey-dew, the defoliation would cease.

The general deterioration of shade trees which has been noticeable for the last six or seven years has been even more pronounced the last two years. The trees showing the most deterioration are the elm, maple, white and black ash, butternut and Norway spruce; and the sycamore showed winter killing of the twigs last season, with a Glœosporium infection of the foliage. The roots of the elm, maple and oak are constantly dying back, and for the last two years maples have been showing what is termed "staghead," supposed to be due to a diminution of water in the soil in some cases, and in others winter killing of the roots is no doubt a contributing factor. Many thousands of maples have been so affected in the northeastern United States. Last winter was one of the worst on record for depth of freezing, and vegetation in general was in poor condition, owing to the drought, to enter upon even a mild winter. The freezing of gas and water pipes was of so frequent occurrence as to cause an unprecedented number of leaks. In one city with about 50 miles of pipes, over 200 leaks were recorded, the loss of gas amounting to about 33 per cent., and in some cases sections of the supply had to be cut off. Thus it is not surprising that winter injury of various kinds occurred, although to what extent vegetation has suffered we cannot tell as yet.

A NEW RUST.

G. E. STONE.

Currant Rust, White Pine Blister Rust.

In previous reports we have mentioned an epidemic of rusts which have been unusually severe the past few years on the apple, bean, quince and ash, and last year we noted a new rust on Vinca. A new form has lately made its appearance on the black currant. The white pine blister rust has also been with us for several years, affecting most largely young nursery stock, although it is occasionally found on white pines of fairly good size. On September 28 some specimens of currant rust were sent in from a large estate in Essex County, this being the first outbreak recorded in Massachusetts to our knowledge. At practically the same time Dr. G. P. Clinton observed a similar outbreak in Connecticut, and Prof. F. C. Stewart, of the Geneva Experiment Station, noted an outbreak in New York.

The rust in this State is confined, so far as we know at the present time, to one block of 200 currant plants of the Black Champion variety. The plants were two-year-olds, purchased last spring from a New York nursery, and practically all in this block were infested except about twenty-five or thirty in the southwestern corner of the block. About a quarter of a mile south of the diseased currants was a small block of old black currants, but they showed no signs of Cronartium. About the same distance east was a magnificent stand of eight-year-old pines, but rigid examination failed to reveal any signs of blister rust infection; neither was any infection found on the near-by block of red currants.

The following description of the currant rust and white pine blister rust, which are different stages of the same rust, was prepared at my request by Mr. E. A. Larrabee, from various literature.

The white pine (*Pinus Strobus*) blister rust (*Peridermium Strobi*) has only been known in Germany for the last thirty or forty years. In this country it has been discovered within the last few years. In 1906 Dr. F. C. Stewart of the Geneva station in New York found the disease on the grounds there, but prompt and radical treatment is believed to have completely eradicated it. Again, in 1909, it was found in New York State on a shipment of three-year-old white pine seedlings from Germany.

This fungus has two well-known forms which have in former years been described as two distinct species, — one appearing on the currant and gooseberry (*Ribes*), and the other on the white pine. The stage found on the Ribes bushes was discovered and named about fifty years ago by Dietrich, while the stage on the pine was discovered and named by Klebahn in 1887. Since this time, however, by careful and extensive inoculation experiments, it has been conclusively proved that *Peridermium Strobi* on the pine, and *Cronartium ribicola* on Ribes are not two distinct species of fungi, but are different stages of the same organism.

Unfortunately, the presence of this fungus is not apparent at or before planting time. It is particularly noticeable in this country probably during the month of May. It then covers the trunks of young pines of four or five years and over, as well as the trunks and branches of older pine trees, with bright yellow blisters in which are contained the æcidiospores. These æcidiospores appear as a dark yellow powder and cannot germinate unless they fall on the leaves of currants or gooseberries (*Ribes*). On these leaves, however, they develop, send germ tubes into the leaf tissue, and there form a heavy matting of mycelium. Along about the middle of June there are formed on the under side of the leaves of these Ribes plants bright yellow deposits (uredospores) which spread the disease from leaf to leaf on these plants. These uredospores continue to spread throughout the Ribes during the entire season in which young leaves are formed. In the summer, too, still another reproduction cell is found in the shape of yellow-brown strings or sacs, of about the thickness of a hair, on the under side of the leaves of the Ribes bushes, and these are known as teleutospores. On the surface of these so-called strings are deposited tiny cells known as sporidia. These sporidia will germinate only on the bark of young shoots of the white pine.

The so-called sporidia are produced and carried about by the wind at the very season when the young pine shoots have begun to develop and are in a condition to be readily infected. When the small sporidia germinate they send their germ tubes into the tender bark of the white pine, and there the mycelium again forms a heavy matting. This tissue lives for many years in the branches, and occasions considerable swelling of the shoots, by which the disease may be detected in the fall and winter, when there are no yellow deposits on the bark. These swellings often do not show on the white pine for perhaps a year or more. It is probably several years after infection before these dark yellow spore blisters are formed, but when they once appear they often reappear every spring for a number of years on the same swellings. Their appearance is preceded by the formation of very small dot-like heaps of spores which are called spermogonia. These spermogonia contain sweet-tasting, sticky spores, so-called spermatia, about which nothing is known.

It will be seen from the preceding that this disease cannot spread from one pine to another. It must first go from pine to Ribes (in May or June) and from Ribes back to pine (in August or September). In the trunks of pine trees the fungus is perennial, but on Ribes it affects only the leaves and cannot live over winter.

While it would appear from this description of the rust that an alternation of hosts is necessary in the case of currant rust, some American pathologists would question this, and observations made by some investigators on the rust in this country seem to indicate that the rust may be able to propagate indefinitely on the currant without the intervention of the pine.

At the request of Professor Stewart we are therefore conducting experiments to determine whether reinfection of currants can occur without the intervention of the pine. These are now being carried on in our greenhouse, together with some other experiments relating to the control of the disease; and work along the same lines is being done by Dr. Clinton in Connecticut.

This disease on the currant can undoubtedly be eradicated by some method of spraying, but if not, it may be necessary to destroy all the black currants in the State, as they are not of great economic importance. The white pine blister rust is being carefully looked after by Dr. H. T. Fernald, State Inspector of Nurseries.

EFFECTS OF ILLUMINATING GAS ON VEGETATION.

G. E. STONE.

It is well known that escaping illuminating gas in the soil has an injurious effect on vegetation, and occasionally kills trees. In States where records[1] are required of the amount of gas manufactured, and that unaccounted for, the loss is found to amount to considerable in some cases, but this does not always mean that all unaccounted-for gas escapes in the soil or air, since these measurements are dependent on different meter readings. The meters may run too slow or too fast, requiring a great deal of care to warrant any degree of accuracy. Moreover, gas varies greatly with temperature, and even 6 or 8 per cent. of unaccounted-for gas is not necessarily all leakage.

There are several kinds of gas used for lighting and heating, *i.e.*, water gas, coal gas, gasoline gas, acetylene gas and others, but their effects on the plant are quite similar, and they are all very poisonous to vegetation. Even the same kind of gas varies to quite an extent, as the process of manufacture is not always the same. This difference in composition is often very slight, but to any one who has had experience in diagnosing trees killed by gas it is discernible; for example, the gas manufactured by one corporation will produce different effects on a tree from that manufactured by another; yet gas from the same plant differs very little as a rule.

Illuminating gas is very poisonous to vegetation. The poisonous properties are largely confined to the numerous products which are absorbed by the soil moisture in small quantities, taken up by the roots and translocated through the tissue.

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[1] Consult Ann. Repts. of Inspector of Gas Meters and Illuminating Gas, Mass. Public Documents, No. 55; Ann. Repts. of Board of Gas and Elec. Light Comm., Mass. Pub. Documents, No. 35.

These substances are to be found in the tissue, although, as already pointed out, the reactions are not quite the same in different places nor on different species of trees. Trees poisoned by illuminating gas usually show some characteristic post-mortem symptoms, but many of these symptoms may be found in trees dying from other causes. More or less rapid deterioration and increased brittleness of the wood is a quite characteristic symptom, however.

In summer the first effects of gas poisoning may be seen in the foliage. The leaves turn yellow and in some cases drop off, while the leaves of other trees fall while still remaining green, and in still other cases the trees do not become defoliated but the leaves turn a reddish brown and die. The upper part of the tree, being far away from the source of water supply, usually shows the effects first. All this occurs before there is any evidence of abnormal tissue above ground. The water contents of the soil containing the poisonous principles of gas pass up through the roots and stems, and later the wood and zone constituting the living portion of the trunk become abnormal. The first symptoms appear in the characteristic dryness of the cambium and other tissues outside the wood, this being the first indication of the approaching death of the tissue. Later these tissues, — cambium, phloem and cortex, — turn brown and disintegration follows. These abnormal conditions first take place in the roots, which are the first to absorb the poison, but later, as absorption and translocation proceed, the poisonous constituents may be detected in the wood, etc., at the base of the tree. It not infrequently happens that the tissue at the base of the tree is dead, while that in the trunk a few feet above is alive. But this condition does not endure, for sooner or later the whole tree becomes involved. When the underlying tissues, cortex, phloem, etc., die, the bark changes color, gradually growing darker, the tissue tensions are destroyed, and the physical properties of the bark are greatly changed. Soon various species of fungi, such as *Polystictus, Schizophyllum* and others, find a foothold on the bark and borers and other insects attack the dead tissue. Even bacteria and molds, like *Penicillium*, become active and hasten the process of disintegration, the smaller twigs becoming dry and brittle, and the ends are often broken off. The upper limbs usually lose their bark first, and eventually the larger limbs present the same appearance. Disintegration may become so rapid that in one and a half to three years most of the larger branches will break off, and soon nothing but a portion of the trunk and a few stubs remain.

All these conditions refer merely to the way in which a tree succumbs to gas poisoning, and do not necessarily constitute reliable symptoms of this type of injury, as these symptoms may be found in trees dying from other causes. The tissue furnishes the most reliable symptoms for diagnosis. The writer has for years been examining thousands of trees killed by gas, and has taken exhaustive notes on every symptom shown by trees dying from various causes, and from the first it was found necessary to make a thorough examination of the tissue to warrant any degree of accuracy in the diagnosis. From these notes may be had much interesting data on the relative importance of various symptoms. Since some of the poisonous constituents of illuminating gas are absorbed by the roots and are circulated to a certain extent through the tissue of the wood, it becomes necessary to note these substances and learn to detect their presence, either by chemical means or from direct observations and experience.

As already stated, no two species of trees present precisely the same symptoms, much variation occurring from location, seasons, etc. A certain species, for example, examined in the fall, will show slightly different symptoms from those given by a spring examination, and this is true of trees poisoned by gas from different manufacturing plants, due undoubtedly to the fact that there is considerable difference in the gas manufactured by different concerns. The different chemical constituents of the soil in remote localities might to a certain extent be held responsible for the variations in the reaction of gas on the tissues, but this is probably not very important, since these variations are likely to occur even in a single town supplied from one source, and as a rule the symptoms in trees injured by gas from a single manufacturing plant are alike. From tables giving the results of gas analysis from various corporations we find that there is considerable difference in the composition of gas, and furthermore, that gas from a single corporation is likely to vary from day to day to some extent. This variation is not only found in the different percentages of gas constituents but in the other products.

The principal features in the tissues from which diagnosis may be made are odor and color, although it is possible by the use of chemicals to obtain reactions and to detect certain products in the tissue of trees killed by gas. There are different odors associated with the wood of trees which die from various causes, and it is necessary to become familiar with these to be able to differentiate them. Molds and other micro-organisms acting on the sap of trees dying from various causes often cause decomposition, with certain resultant odors which occur in a great variety of trees. But always in trees killed by gas may be found peculiar characteristic odors difficult to describe, even if the tissue most seriously affected is found. This tissue is usually at the base of the tree or in the larger roots near where the tissue has absorbed the most poison, and it is more easily recognized after a tree has been dead for a few weeks or months. The odor is more prominent in moist than in dry trees. It can be detected in the tissues of the bark as well as of the wood.

Sometimes this odoriferous wood is found deeper in the sapwood than at other points, and can be recognized in the stumps of trees freshly cut, but in old stumps where decay has set in it is not always discernible. In such cases some part of the root system, if dug up, is likely to give a characteristic odor except when the wood has become too dry and a more or less advanced stage of decay has set in. As previously stated, the odors are difficult to describe, as they are often associated with the products of decomposition. Moreover, the odors of one tree are entirely different from those of another, so one has to become familiar with the characteristics of each species of tree which he is diagnosing. The natural odor of the maple is quite different from that of the elm, horsechestnut or red oak, and their products of decomposition differ also. Nevertheless, the characteristic odor given to the tissue by the products of illuminating gas can be differentiated quite easily and accurately by any one familiar with them. Sometimes these odors are found in a considerable part of the tissue of the trunk, but more often they are confined to some special part of the tree or root. They are more pronounced by far at the base of the tree than above, and in the top are rarely to be noticed.

We know of no remedies which can be applied to trees already poisoned by gas, since the injury occurs below the surface of the ground, and the effects on the tree are seldom noticeable until the poisoning is more or less pronounced. If the leakage of gas could be discovered quickly and the leak repaired, the effects on the roots might be prevented, but this is rarely the case. In some instances where only one root has been affected, and the poison has not reached the trunk of the tree, amputation of the root is used to prevent further harm, and we have seen cases where this has proved effective. There are many cases where trees have not suffered from gas poisoning although located near large leaks, because in the installation of curbings many of the larger roots were destroyed which grew over the roadbed where the gas pipes were laid.

When the soil is charged with gas, excavating and aerating are beneficial, and in the case of severe leakage it is well to leave the trench open for a few days, if possible. On the other hand, boring holes in the soil and filling with water is of absolutely no value. It is generally believed that if young trees are planted near others which have died from gas poisoning they will not live, but this is true only in part. If the soil is thoroughly saturated with gas, bad results may follow, but if young trees are planted in fresh loam and the old soil aerated there is little likelihood of the tree dying. It is possible, but perhaps at the present time not practical in all instances, to prevent injury to trees and asphyxiation to people in houses from gas leaks, and undoubtedly in the future better methods of distributing gas will be employed.

SUMMARY.

The symptoms of gas poisoning are best obtained from a careful examination of the wood at the base of the tree or the roots. This can be done when the poisonous principles have reached a certain point in their ascent. There are many symptoms accompanying gas poisoning such as a yellowing of the leaves, drop-ping off, peeling of the bark, presence of certain fungi, etc., but they are of no value in themselves, as these symptoms may accompany other causes of death.

THE EFFECT OF ILLUMINATING GAS ON FOLIAGE.

Gas from soil leakage seldom escapes into the atmosphere sufficiently to cause direct injury to foliage, although trees are sometimes injured near gas-manufacturing plants, where there is usually a strong odor of gas. Atmospheric gases of all kinds are quickly dispersed, especially when there is any circulation of air; yet under certain conditions they cause injury to plants, as is well known. The leakage of illuminating gas from soil pipes is seldom sufficient in quantity or prolonged enough for it to injure the foliage of trees and shrubs.

The trees in large cities often suffer greatly from atmospheric gases, of which the most injurious are those arising from coal combustion. The escape of illuminating gas into sewers and conduits is not uncommon. If an untrapped greenhouse drainage system connects with a sewer containing gas, the gas is likely to find its way into the greenhouse and injure the plants, and we have known of large greenhouses losing many plants in this way, the gas escaping into the greenhouse for long periods in such minute quantities as to be scarcely perceptible to the sense of smell. Last winter, when the upheaval of the ground from frost did great damage to gas and water pipes, the gas from a leak near our greenhouse found its way to a drain tile leading to the house some distance from the source of leakage, defoliating a large number of our plants in a few hours. A rose plant which was in perfect condition the night before was found the next morning with most of its leaves turned yellow, and 50 or more per cent. of them had fallen. The plants most severely affected were roses, geraniums and abutilon, but ivy, Eucalyptus, India rubber plants, willow, Kenilworth ivy, papyrus, tobacco, tomato and Sedum were also injured. The ferns, mosses and liverworts, which were nearest the gas inlet, were scarcely touched. After being defoliated, the geraniums and abutilon produced numerous small leaves, and the leaves on the variegated abutilon came in entirely green.

Hartig[1] mentions that Camellias, azaleas and ivy are very sensitive to escaping gas, the least sensitive being palms and Dracænas. It would appear that the higher plants are more susceptible to gas than the lower ones. This might be explained on the assumption that the lower plants, being descendants of very old types which in past ages may have been adapted to different atmospheric conditions, possibly inherit a wider range of adaptability, with consequently less liability to injury.

Effects of Illuminating Gas on Carolina Poplars.

Our attention has been called at different times by Mr. James Walker, of the Newark Shade Tree Commission, Newark, N. J., to a peculiar effect which poisoning from illuminating gas has on Carolina poplars (*Populus deltoides* Marsh).[2] This tree is used extensively for shade in New Jersey, but has recently come into disrepute owing to the havoc which its vigorous root system raises with sewers. Some of these characteristic toxic effects consist in a splitting of the bark and swelling and bulging of the tissue near the lesions, and later a slimy, mucilaginous mass exudes from the cracks.

This last season we examined a Carolina poplar which displayed, in addition to the usual symptoms of gas poisoning, this peculiar swelling and cracking of the bark, and some of the tissue was gathered for histological examination. The tree in question was 7 or 8 inches in diameter near the base, and at the time of observation, in common with most trees affected by gas poisoning, had no leaves. The bark, cortex, etc., on the trunk towards the source of absorption showed three or four vertical cracks or lesions ½ to 2½ feet long. The bark on the sides of these cracks was bulged out considerably, and examination showed a thick layer of soft, parenchymous tissue extending to the wood and apparently derived from the cambium zone. This tissue at the time of observation was perfectly white and fresh in appearance, was easily broken and apparently as delicate as the tissue of an apple. Later the tissue turned brown and disintegrated and became slimy in appearance. This breaking down of the tissue takes place in the more advanced stages of disintegration and, according to Mr. Walker, this broken-down mucilaginous substance exudes from the cracks. Specimens of the bark and tissue showed this soft layer, which was thicker directly under the cracks, where the tension was less, to be anywhere from ½ to 1½ inches thick. Microscopic examinations showed the fresh tissue to be composed entirely of thin-walled parenchyma cells.

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[1] R. Hartig, "The Diseases of Trees."

[2] We have heard the opinion expressed at different times that Carolina poplars are immune to gas poisoning, but there is no foundation for this statement.

In the illustration, 1 shows an enlarged cross section of a piece of normal bark; 2, a cross section of the bark near one of the cracks; 3, a cross section of bark and wood and the abnormal parenchymous growth; and 4, a cross section of the normal bark, including some of the wood. In 2 and 3 the abnormal growth is shown at *e*. In 3, which is an enlarged section, the nature of the tissue is readily seen, as well as its origin from the cambium *f*. In 5 is shown a diagrammatic cross section of tree, with lesions.

This peculiar cracking characteristic of Carolina poplars poisoned by gas has never been observed by us in other species, although like effects have been noticed in willow cuttings growing in water charged with gas, in which case we have often noticed a splitting of the bark and slight swelling, followed by the formation of a mucilaginous mass under the bark. The bark of most trees poisoned by illuminating gas remains intact until it becomes very dry and brittle, and then it cracks, curls up and eventually falls off. There is, however, no disposition in other trees, so far as noticed, for the tissue to become mucilaginous. In some cases of poisoning of coniferous trees the bark may become ruptured and a copious flow of pitch follow. This tissue is apparently what is termed by Hartig "wound cambium," and we have never seen it forming on poplars as the result of ordinary mechanical wounds.

During the past season we have noticed a number of cracks on small poplars (*Populus tremuloides*) apparently resulting from frost injury. But in this case there was no abnormal development of the cambium.[1]

When banding substances are applied to Carolina poplars

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[1] The injection of poisons into tissue is said to cause a rupturing of the tissue owing to changes in the turgescence of the cells.

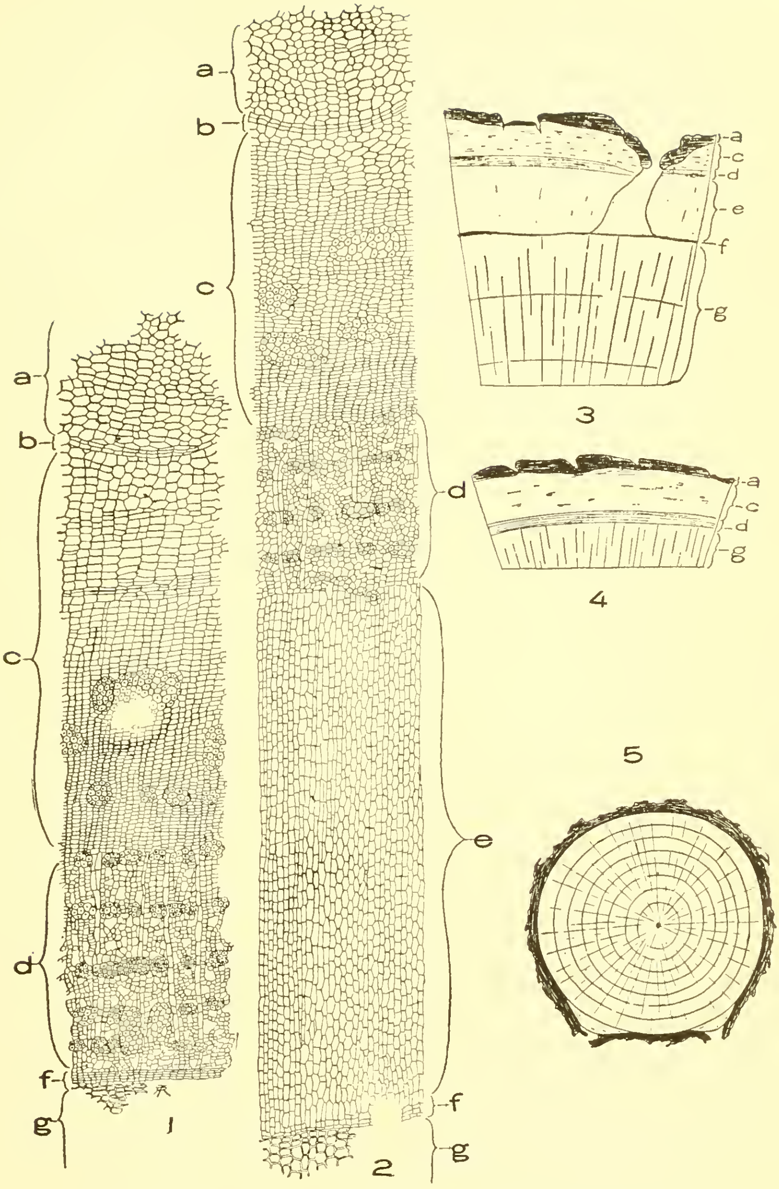

FIG. 1.—Showing cross section of Carolina poplar (*Populus deltoides* Marsh). 1, Cross section of normal stem, enlarged; 2, same, showing abnormal growth; 3, naked-eye view of same; 4, section of a normal stem; 5, cross section of trunk of tree showing the splitting of the bark; *a*, bark; *b*, cork cambium; *c*, cortex; *d*, phloem; *e*, abnormal parenchyma; *f*, cambium; *g*, wood or xylem.

and other trees to trap insects, injury often results to the tissue, with swellings and distortion where the substances come in contact with the bark. We have seen many trees affected in this way in the eastern part of the State, where much use has been made of banding substances for the extermination of the gypsy moth. Their effect is more pronounced on Carolina poplars than on other trees, and it is not improbable that this cracking and abnormal formation under the bark results from decreased turgescence of the cell and destruction of the outer tissue, thus relieving the tension on the inner tissue and causing the cambium to divide. With the release of the pressure outwards, it is natural for this tissue to extend in this direction, thus rupturing the outer bark. The absorption of the gas may have killed the tissue exterior to the cambium layer before the cambium was affected. In this way, the tension of the outer tissue being diminished, a stimulation of the cambium cells results.

The poisonous constituents of gas have a direct stimulating effect on the cells during the incipient stage of poisoning, as observed in the case of willow cuttings, etc.; but in this instance it would appear that the excessive development of the cambium was caused by the diminished tension of the cortical tissue.

Stimulating Effects of Illuminating Gas on Willow Cuttings.

For many years we have been studying the effects of different gases on the functions of plants, and during this time we have made many experiments relative to the effects of water charged with illuminating gas on the development of willow cuttings. It is well known that there are many chemical substances which stimulate plants. Even the most violent poisons, if administered in certain dosages, will greatly increase plant activities; for instance, ether is well known to cause latent buds to blossom, and some use is made of it by commercial florists.

Illuminating gas is a deadly poison both to the foliage and root systems of plants; but when administered under certain conditions is a great stimulant. Latent willow cuttings grown in water charged with illuminating gas for a few moments every day or two showed a greatly increased development, producing foliage several days earlier than plants grown in water not charged with gas.

The results of experiments with latent willow cuttings grown under these conditions are shown in Table I. The cuttings were grown in glass jars containing about 2 litres of water which was charged at different periods, as shown in the following table: —

TABLE I. — *Showing Stimulating Effects of Illuminating Gas on Willow Cuttings grown in Water charged with Gas.*

[In all experiments except No. 1, 8 normal and 8 treated cuttings were used in each series.]

Experiment.		First Appearance of Leaves and Shoots.	Gain in Development (Days).	Water charged with Gas for a Brief Period.
1	Normal,	August 19	9	Every second day.
	Treated,	August 10		
2	Normal,	December 10	8	Every second day.
	Treated,	December 2		
3	Normal,	January 4	8	Every second day.
	Treated,	December 27		
4	Normal,	December 29	6	Every second day.
	Treated,	December 23		
5	Normal,	February 4	11	Every second day.
	Treated,	January 24		
	Treated,	January 22	9	Every fourth day.
	Treated,	January 24	11	Every sixth day.
6	Normal,	February 20	5	Every second day.
	Treated,	February 15		
7	Normal,	March 25	6	Every seventh day.
	Treated,	March 19		
8	Normal,	April 24	5	Every second day.
	Treated,	April 19		
	Treated,	April 20	4	Every fourth day.
9	Normal,	July 18	4	Every second day.
	Treated,	July 14		

The data given in this table show that the willow cuttings contained in the charged jars developed new shoots and foliage from four to eleven days earlier than those grown in jars containing the ordinary uncharged tapwater. They also show that

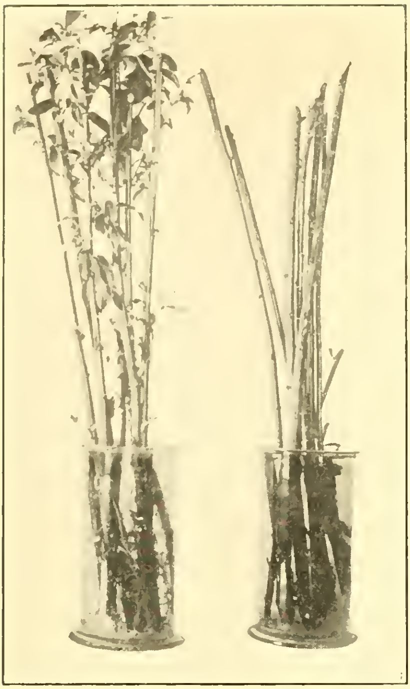

FIG. 2.— Showing willow cuttings growing in water; those to the right, in ordinary water, those to the left, in water charged with gas.

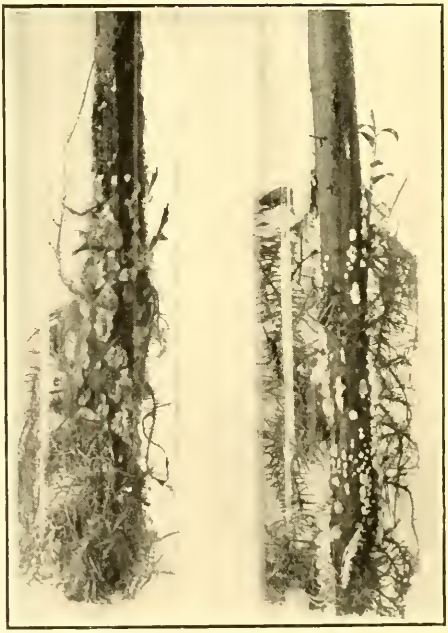

FIG. 3. — Showing development of lenticels on willow cuttings growing in water. Figure to the right growing in ordinary water; to the left, in water charged with gas.

there is practically no difference in the development of the cuttings, whether the jars were charged with the gas every second day, every fourth day, etc. (Fig. 2).

The duration of these experiments was from one to two months. In some instances the plants showed more or less advanced symptoms of gas poisoning at the close of the experiment, and the oftener the water was charged with gas the quicker the symptoms appeared and the more pronounced the poisoning. The same stimulating effects were shown on the roots as on the stems and leaves.

Table II. gives the results with both shoots and roots as determined by the average length, as follows: —

TABLE II. — *Showing the Stimulating Effects of Illuminating Gas on Willow Cuttings grown in Water charged with Gas.*

[Eight treated and 8 untreated cuttings used in each series. All measurements given in centimeters.]

EXPERIMENT.		AVERAGE LENGTH OF —		PERCENTAGE GAIN IN AVERAGE LENGTH OF —	
		Shoots.	Roots.	Shoots.	Roots.
1	Normal,	2.50	2.00	–	–
	Charged every second day,	6.00	8.00	140	300
2	Normal,	1.50	2.00	–	–
	Charged every second day,	5.00	6.00	233	200
3	Normal,	1.00	3.00	–	–
	Charged every second day,	4.00	6 00	300	100

In this table the average length of stems and roots is given, together with the per cent. gain in average length of each. Only three experiments are given. It will be noticed that there was considerable gain in the average length of roots and shoots of the cuttings grown in gas-charged water.

Another similar series of experiments is shown in Table III., as follows: —

TABLE III. — *Showing the Stimulating Effects of Illuminating Gas on Willow Cuttings grown in Water charged with Gas.*

[Eight untreated and 8 treated cuttings used in each series. All measurements in centimeters.]

EXPERIMENT.		Total Number of Times charged.	TOTAL NUMBER OF —		TOTAL LENGTH OF —		AVERAGE LENGTH OF —		PERCENTAGE GAIN IN AVERAGE LENGTH OF —	
			Shoots.	Roots.	Shoots.	Roots.	Shoots.	Roots.	Shoots.	Roots.
1	Normal,	–	8	9	2.00	11.10	.25	1.20	–	–
	Charged every second day,	15	53	82	164.00	294.00	3.09	3.58	1,096.00	198.38
2	Normal,	–	35	40	178.50	196.00	5.10	4.90	–	–
	Charged every second day,	34	36	156	212.40	113.88	5.90	7.30	15.68	48.98
3	Normal,	–	30	42	125.60	111.10	4.18	2.64	–	–
	Charged every second day,	24	24	142	161.30	703.90	6.72	4.95	36.89	87.50
	Charged every fourth day,	12	32	161	178.60	1,000.10	5.58	6.21	33.49	135.22
4	Charged every sixth day,	6	30	151	204.70	753.20	6.82	4.98	63.15	88.67
	Normal,	–	32	39	140.90	104.40	4.40	2.67	–	–
	Charged every second day,	24	13	127	162.20	677.90	12.47	5.33	183.40	99.90
	Charged every fourth day,	12	38	131	344.50	932.90	9.07	7.12	106.10	166.60
	Charged every sixth day,	8	30	145	295.10	776.40	9.83	5.35	125.60	100.40

Summary of Table III.

	Number of Plants.	Average Number of —		Average Length in Centimeters of —		Per Cent. Gain in Average Length of —	
		Shoots.	Roots.	Shoots.	Roots.	Shoots.	Roots.
Normal, . . .	32	26	32	111.75	105 90	-	-
Treated, . . .	64	32	138	215.35	656.53	92.7	519.9

This series of experiments was conducted like the preceding, except that measurements were made of the total number and length of shoots and roots, which was greater in the gas-charged water. The average number of shoots in the treated water was 32, and of those in the normal or untreated, 26, while of the roots, the average for the treated water was 138 and for the untreated, 32. The stems and roots in the charged water greatly exceeded in development those in the untreated water, and appeared much earlier.

From these data it will be seen that the effects of gas in increasing the number of roots are quite noticeable. Similar results are shown with the total length of shoots and roots; for instance, the cuttings growing in the charged water grew longer roots and shoots than those in the untreated water. It will also be noticed that the total length of roots is relatively greater than the total length of shoots. The average total length of the normal, untreated shoots was 111.75 centimeters, of the treated shoots, 215.35 centimeters. The average length of the normal roots was 105.90 centimeters, and that of the treated, 656.35 centimeters. The average gain of the treated over the untreated shoots was 92.7 per cent., and that of the treated over the untreated roots was 519.9 per cent. The percentage gained in average length of shoots and roots in each experiment ranges from 15 to over 1,000 per cent. in favor of those grown in gas-charged water.

In summarizing the results of these experiments it may be said that there was little difference in the average number of shoots in the normal and treated, but the average number of roots in the treated shoots exceeded those of the normal; furthermore, the total and average length of roots and shoots in the treated water greatly exceeded that in the untreated. While only a slight difference was shown in the number of shoots in the normal and treated willow cuttings, the latter showed a greater development. The increased development of the shoots and foliage was correlated with the greater root development. We regard the increased root development of the treated willow cuttings as a direct response to oxygen supply. The roots of cuttings growing in the charged water were invariably more slender than those in the untreated, and were also characterized by an early appearance of a profuse growth of secondary roots.

Effects of Illuminating Gas on Lenticels.

The lenticels or breathing pores of the willow cuttings grown in water charged with gas showed a marked difference in development. They always show a greater growth in water, but the development of the parts submerged in water charged with gas was exceptional. Many years ago Nobbe [1] observed when conducting water culture experiments with potatoes that the submerged tubers developed unusually large lenticels.

This stimulation of the lenticels was one of the most conspicuous reactions we observed in our experiments with willow cuttings, and appears to be a general response to a demand for oxygen. (Fig. 3). The gas in the treated water had practically the same asphyxiating effect on the plant as a decreased supply of oxygen, the demand for oxygen being increased and the plant responding by a greater growth of the lenticels.

The response on the part of the roots of the willow cuttings to the stimulating effects of gas appears to be the same type of reaction, *i.e.,* practically amounting to a decreased oxygen supply. Observations on plants grown under a diminished atmospheric pressure have given somewhat similar results to those shown by the willow cuttings; that is, they grow more rapidly than those under normal conditions. This is not, however, the effect of the diminished pressure alone, but is due to a diminution of the partial pressure of oxygen. Wieler and Jaccard [2] have demonstrated that the optimum growth of plants does not correspond to the normal atmospheric pressure. According to Jaccard, a decrease in the pressure of oxygen gives rise to an accelerated growth and more profuse branching of the axis and roots, together with an increase in the size of the leaves. The water containing gas is taken up in small quantities by the roots and translocated to the stem and leaves, and since plants possess considerable power of accommodation they can do this for quite long periods without injury.

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[1] Landwirtsch. Versuchstation, Vol. IV., 1864, p. 60.

[2] Schimper's Plant Geography, p. 69.

Plants, like animals, respond to stimuli arising from various causes, and while plants may not respond as quickly as animals, their sensitiveness is in many instances more acute. Specific stimuli give rise to definite responses, and the nature of the response usually corresponds with some immediate need of the organism. The presence of water charged with gas in the plant tissues stimulates the demand for oxygen, which is manifested in a greater root development and leaf surface.

Man and animals respond characteristically when subjected to a decreased oxygen supply such as is caused by unusual exertion like mountain climbing, running, etc. Dogs open their mouths, run out their tongues and breathe more rapidly when excited, and this is in reality a response to the demand for more air or oxygen. In the same way, the increased size of lenticels is a direct response to the demand for oxygen, although in the case of both animals and plants it is purely reflex and involuntary.

Illuminating Gas as a Factor in Forcing the Development of Plants.

The stimulating effects of gas-charged water on willow cuttings led us to experiment with illuminating gas in other ways, therefore a number of experiments were made to determine the effects of atmosphere charged with the gas on the development of dormant willow cuttings. Ether and other substances have been used to stimulate plants in a dormant condition, and we wished to learn whether gas would have the same effect.

The willow cuttings were placed under sealed bell jars in vessels of water and subjected to an atmosphere of illuminating gas for twenty-four, forty-eight, seventy-two, ninety-six and one hundred and twenty hours, respectively. A number of cuttings were used in each test, and after being treated for these different periods they were removed from the bell-jars and placed under greenhouse conditions to await the results of treatment. When these cuttings were compared with untreated or normal plants, as they were in all cases, a slight acceleration was found in the development of all plants subject to gas for twenty-four, forty-eight and seventy-two hours, although the gain was not marked.

THE INFLUENCE OF VARIOUS LIGHT INTENSITIES AND SOIL MOISTURE ON THE GROWTH OF CUCUMBERS, AND THEIR SUSCEPTIBILITY TO BURNING FROM HYDROCYANIC ACID GAS.

G. E. STONE.

The influence of light on photosynthesis, structure and development of plants is well known to plant physiologists, but is too little appreciated by growers of crops, whether under glass or in the field. It is also well known that plants grown in the dark are pale and slender, with undeveloped leaves, and they quickly wilt and die when exposed to different temperatures and light conditions. The variations in light intensity in the greenhouse or in the field, such as occur in periods of cloudy weather, affect crops greatly. There are many features connected with greenhouse construction, such as inferior or dirty glass, angle of the roof, heavy shadow-casting frames and others which also play an important part in plant development. Certain light-requiring crops grown under the inferior light conditions of November and December develop abnormally, and often suffer greatly from wilts in the spring when the light is more intense. The plants possess light-colored, thin leaves, elongated and slender internodes and leaf petioles, and, in fact, are in a state of partial etiolation.

Light inhibits growth and has a remarkable effect on the texture of plant tissue. While it has a great deal to do with the non-ripening and ripening of wood, moisture, temperature and other factors also enter in.

The successful growing of lettuce under glass requires exceptional skill, as much attention has to be given to the influence of light, moisture and other factors on the crop to prevent what is termed "topburn," a certain texture being required to do this. Even a difference of a few degrees in the night temperature exerts marked influence on the texture of the tissue. Lettuce plants which are grown under a night temperature of 45° F. differ greatly from those grown at a temperature of 50° F., the structure of the plant being modified for each degree of increase or decrease in the temperature. With the lower night temperature there is less likelihood of burning than with the higher. If a night temperature of 50° F. is maintained during cloudy weather, and on a following bright, sunshiny day the temperature is allowed to reach 75 or 80° F., topburn is likely to occur. On the other hand, a night temperature of 40° F., during cloudy periods followed by a relatively high day temperature, is not likely to produce any burning.

Light has a marked accelerating effect on transpiration, as the stomata of the leaves open in bright sunshine, and the loss of water from the foliage under these conditions is large. In the blossom end rot of tomatoes, a disease caused primarily by heavy drainage of water from the fruit during its development, we have noted a difference of 35 per cent. in the amount of rot, caused by the shading of the tomato plants by other plants, reducing the transpiration.

Practical growers who have had occasion to fumigate greenhouses to destroy aphis, white fly and thrips have observed that their plants will burn slightly at one time and at other times not; for instance, hydrocyanic acid gas, tobacco leaves or concentrated solutions of tobacco, and other fumigants sometimes cause injury to plants and at other times produce no burning. This is also true of spraying mixtures, whether used in the greenhouse or field.

The experiments given here are designed to show some of the causes underlying burning from fumigation, and were made by Mr. F. L. Thomas during his course as a graduate student. The plants selected were cucumbers, as they are susceptible to burning from various causes, and are also affected greatly by variations in light intensity. The plants were grown under five cloth screens, ranging in grade from mosquito netting to rather finely woven cotton material, each covering a space 2 feet wide, 6 feet long and 2 feet high on a long bench in the greenhouse.

The normal plants were grown in the same bench but were not screened, and the light conditions were the same as those in the greenhouse. The house is new and the light excellent, — only about 18 per cent. less than out of doors. The relative light intensity under the various conditions varied sufficiently to cause considerable difference in the development of the plants. These differences were determined by chemical methods accurate enough to warrant the average relative light conditions being obtained, but not adapted to measure the absolute light intensity.

In the following tables are given the results of experiments with the effects of different light intensities on the growth of cucumber plants and their susceptibility to burning from hydrocyanic acid gas. In each experiment 6 groups of plants were used, No. 5 being grown under normal greenhouse conditions and the others under varying light intensities.

Since two of the screened compartments gave practically the same light intensities, and the results obtained from the plants in these sections were similar, they were averaged together and appear in the table under No. 2. The plants were grown in 7-inch pots and entirely under the screens. The moisture content of the soil was kept fairly uniform in each series. After the plants had reached a certain degree of development they were placed in a tight glass case containing about 30 cubic feet, and each series was fumigated at the same time under similar conditions as regards exposure and the amount of hydrocyanic acid gas. The plants were all fumigated with .007 grams of cyanide per cubic foot, a strength commonly used in greenhouse work, and known as formula [1] 1–2–3, — one part cyanide, two parts sulfuric acid and three parts water. After undergoing this treatment for forty minutes to one hour the plants were removed from the case and the results noted.

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[1] Bul. 123, Mass. Agr. Exp. Station, 1903.

TABLE I. — *Showing Effects of Different Light Intensities on the Growth of Cucumber Plants and their Susceptibility to Burning by Fumigation with Hydrocyanic Acid Gas.*

EXPERIMENT I. — *Duration, May 2 to June 6.*

[Measurements in centimeters.]

	NUMBER.				
	1.	2.	3.	4.	5 N.
Relative light intensity (per cent.),	21.4	26.60	48.10	74.00	100.0
Average height of plants,	13.0	20.10	11.00	17.00	16.0
Average diameter of stem,	.4	.57	.45	.65	.8
Average length of internodes,	5.0	5.90	4.20	4.00	3.7
Leaf: —					
Average length,	7.5	8.60	5.20	9.90	8.7
Average width,	6.5	9.60	6.20	9.20	10.5
Length by width,	48.7	77.10	32.20	91.00	91.3

NOTE. — No. 1, all leaves killed; No. 2, leaves burned, few killed; Nos. 3, 4 and 5 N, traces of burning.

EXPERIMENT II. — *Duration, May 8 to June 13, 1911.*

[Measurements in centimeters.]

	NUMBER.				
	1.	2.	3.	4.	5 N.
Relative light intensity (per cent.),	21.4	26.60	48.10	74.0	100.0
Average height of plants,	30.5	28.30	2.10	27.2	16.0
Average diameter of stem,	.5	.62	.55	.7	.8
Average length of internodes,	8.2	6.60	6.60	4.7	3.5
Leaf: —					
Average length,	9.0	8.10	6.00	5.5	6.2
Average width,	10.5	11.50	9.00	9.5	12.5
Length by width,	91.5	93.70	54.00	52.2	77.5

NOTE. — No. 1, burned; some leaves killed; Nos. 2 and 3, some burning; Nos. 4 and 5 N slight burning.

EXPERIMENT III. — *Duration, May 22 to June 24, 1911.*

[Measurements in centimeters.]

	NUMBER.				
	1.	2.	3.	4.	5 N.
Relative light intensity (per cent.),	21.40	26.60	48.1	74.00	100.00
Average height of plants,	23.50	23.30	20.0	15.70	14.70
Average diameter of stem,	.42	.55	.6	.65	.75
Average length of internodes,	8.70	8.60	7.1	4.45	4.85
Leaf: —					
Average length,	8.50	9.90	9.7	8.70	8.20
Average width,	8.20	10.30	10.5	11.20	10.70
Length by width,	69.70	100.30	101.8	97.40	87.70

NOTE. — No. 1, burned; No. 2, burned; No. 3, slight burning; Nos. 4 and 5 N, no burning.

Summary Table.

[Measurements in centimeters.]

	Number.				
	1.	2.	3.	4.	5 N.
Relative light intensity (per cent.),	24.40	26.60	48.10	74.00	100.00
Average height of plants,	22.30	23.30	17.30	19.90	15.50
Average diameter of stem,	.44	.53	.53	.66	.78
Average length of internodes,	7.30	7.00	5.90	4.30	4.00
Length by width of leaves,	70.90	90.30	62.60	80.20	85.50

It will be noticed that the difference in development of the plants in the preceding experiments arises from the fact that they were growing under varying light intensities. Many physiologists, particularly Wiesner, have studied the effects of light intensities on the conformation of plants, and it is necessary, therefore, to mention only in a general way the modifications caused by light. Altogether too few plants were used to eliminate the differences arising from individual variation; nevertheless, the summary table shows a more or less uniform variation in the development of the plants due to different light intensities.

No. 5N, which was growing in the greenhouse, was taken as a normal for growth comparison. The light conditions for this plant were taken as 100 per cent., and represent those characteristic of our latitude at the time the experiments were made, minus an average loss of about 18 per cent. from the greenhouse glass. No. 4, which was screened, received only 74 per cent.; No. 3, 48 per cent.; No. 2, 26 per cent. and No. 1, 24 per cent. These percentages, of course, are purely relative, and are based on the assumption that the plants under normal conditions in the greenhouse received 100 per cent. of light. It will be observed that most of the injury occurred to those plants growing under the poorest light conditions, and the least where the light conditions were best. In considering the results as given in the summary table, which are more reliable than those in the other tables, as they represent averages, much difference is shown in the development. The greatest average height of the plants and length of internodes were found in those series where the light was less, while, on the other hand, the shortest internodes and greatest diameter of the stems occurred in those plants which received the most light; but the average length and width of leaf were variable, as shown in the table. The data giving average length and width of the leaves were obtained by multiplying the width by the length, and represent fairly well the size of the leaf.

It will be noted that the plants growing where the light was excluded had the largest leaves. The leaf development, of course, varies according to the season, and is also affected by light exposure, methods of pruning, etc., and greenhouse cucumbers usually have much larger leaves than field cucumbers. Whatever the optimum photosynthetic requirements for cucumbers may be, or what relationship exists between the size of the leaves and optimum photosynthesis, we do not know; but the production of larger leaves under certain light intensities is apparently a response to a demand for greater carbon assimilation.

To summarize the results of these experiments: burning from hydrocyanic acid gas is more extensive on plants grown under poor light conditions than where the light is good, showing that weak tissue, such as is produced by inferior light, is more susceptible to burning from fumigation.

Influence of Varying Percentages of Moisture on the Development of Cucumbers and their Susceptibility to Burning from Hydrocyanic Acid Gas.

That the percentage of moisture in soil has an important bearing on crop production, exerting a modifying influence on growth and development, is well understood and usually taken into consideration by experimentalists. Plants will make greater growth in a relatively moist soil, although there is an optimum moisture content of the soil for most plants. Besides growing more rapidly, a plant in a moist soil develops a different type of tissue, which is usually less resistant to various injurious agencies than the dry soil plant. Two or 3 per cent. more water in a plant than what might be considered the normal renders it more susceptible to winter killing, topburn and even fungous infection. Lettuce, for instance, will burn more quickly when the tissue contains more than the usual amount of water, and mildew and rusts are more common on plants with a relatively high water content.

The object of our experiments in growing plants in different percentages of soil moisture was to determine what influence soil moisture had on the development of the plant, with special reference to susceptibility to burning from hydrocyanic acid gas. We used cucumber plants, as before, growing them in small, galvanized iron pots holding about 1½ kilograms of soil. The soil was the greenhouse type, containing considerable organic matter, with a water-retaining capacity of 47 per cent. The total water-retaining capacity of the soil in these experiments was regarded as 100 per cent. The various soils in the pots were maintained at 10, 20, 50 per cent., etc., of the total water-retaining capacity.

After reaching a certain degree of development under greenhouse conditions the plants were placed in a tight case, as in the preceding series of experiments, and treated with .007 grams of cyanide per cubic foot, as before. After treatment the plants were taken out of the case and left for further observations.

TABLE II. —*Showing the Effects of Different Percentages of Soil Moisture on the Growth of Cucumber Plants and their Susceptibility to Burning from the Use of Hydrocyanic Acid Gas.*

EXPERIMENT I. — *Duration, June 5 to June 20.*

[Measurements in centimeters.]

	NUMBER.				
	1.	2.	3.	4.	5.
Per cent. moisture,	10.000	25.0	40.00	55.00	70.00
Average height,	3.300	6.5	8.00	10.50	2.70
Average length of internodes,	2.000	4.7	6.00	4.00	2.00
Average length of petioles,	.750	2.0	3.75	3.66	.75
Average diameter of stem,	.275	.4	.45	.50	.30
Average length by average width of leaf,	1.000	3.0	4.50	4.75	2.00

NOTE. — Nos. 1, 2 and 3, no burning; Nos. 4 and 5, burned.

EXPERIMENT II. — *Duration, March 12 to April 11, 1912.*

[Measurements in centimeters.]

	Number.					
	1.	2.	3.	4.	5.	6.
Per cent. moisture,	10.00	15.0	20.0	50.0	60.0	70.0
Average height,	6.50	8.0	11.0	14.0	18.0	21.5
Average length of internodes,	4.50	4.5	6.0	7.0	8.0	8.0
Average length of petioles,	1.50	1.5	2.5	3.0	4.0	3.0
Average diameter of stem,	.30	.3	.4	.4	.6	.5
Average length by average width of leaf.	6.25	52.0	59.0	185.2	300.0	276.0

NOTE. — Nos. 1 and 2, no burning; No. 3, slight burning; Nos. 4, 5 and 6, nearly all leaves burned.

EXPERIMENT III. — *Duration, March 12 to April 11, 1912.*

[Measurements in centimeters.]

	Number.					
	1.	2.	3.	4.	5.	6.
Per cent. moisture,	10.00	15.0	20.0	50.0	60.0	70.0
Average height,	6.00	7.0	9.5	12.0	17.0	21.0
Average length of internodes,	4.00	4.5	4.5	4.0	7.0	8.5
Average length of petioles,	1.20	2.0	2.0	3.5	4.0	3.5
Average diameter of stem,	.30	.3	.4	.5	.5	.5
Average length by average width of leaf.	6.25	27.0	76.0	140.0	150.0	320.0

NOTE. — Nos. 1 and 2, no burning; No. 3, slight burning; Nos. 4, 5 and 6, nearly all leaves burned.

Summary Table, Experiments II, and III.

[Measurements in Centimeters.]

	Number.					
	1.	2.	3.	4.	5.	6.
Per cent. moisture,	10.00	15.0	20.0	50.00	60.00	70.0
Average height,	6.20	7.5	10.2	13.00	17.50	21.2
Average length of internodes,	4.20	4.5	5.2	5.50	7.50	8.2
Average length of petioles,	1.30	1.7	2.2	3.20	4.00	3.2
Average diameter of stem,	.30	.3	.4	.45	.55	.5
Average length by average width of leaf.	6.25	39.5	67.5	162.50	225.00	285.0

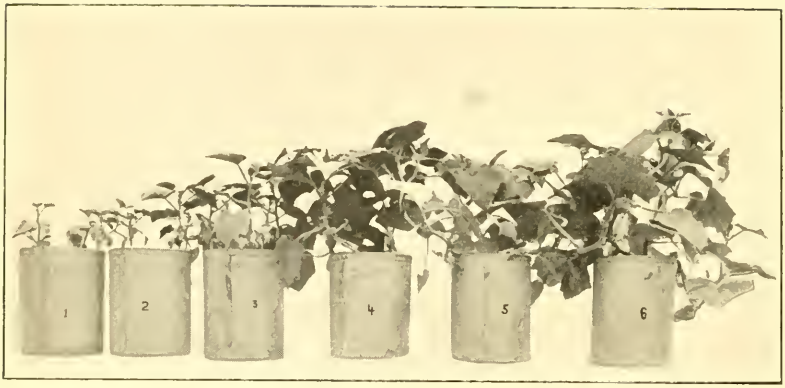

FIG. 1.—Showing cucumber plants growing in different percentages of moisture. No. 1, in 10 per cent.; No. 2, in 15 per cent.; No. 3, in 20 per cent.; No. 4, in 50 per cent.; No. 5, in 60 per cent.; No. 6, in 70 per cent. of the total moisture contents of the soil.

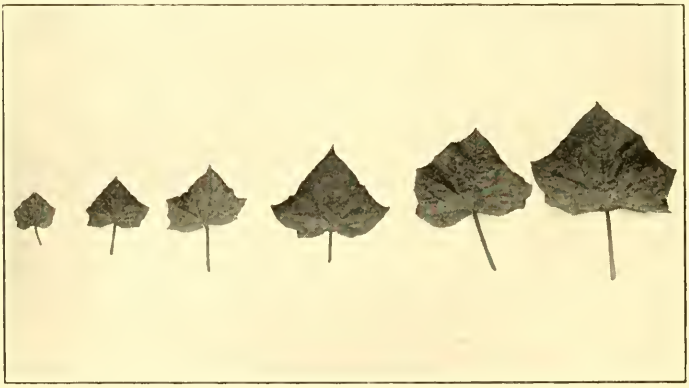

FIG. 2.—Showing leaves taken from cucumber plants grown in different percentages of moisture, corresponding to those shown in Fig. 1.

In the preceding table it is shown that different percentages of soil moisture exert a marked influence on the development of the plants, and their susceptibility to burning from fumigation. It will be noticed (see Summary Table) that the average height of the plants was greater and the leaves larger in the pots containing the largest percentage of water. (*Cf.* Figs. 1 and 2.) Also the diameter of the stems and length of leaf petioles and internodes was greater in the plants growing in a higher percentage of soil moisture, although in the case of the plants growing in pots containing 70 per cent. of water there was too much moisture for the best development.

In Experiment I. the water was supplied largely to the surface of the soil, and in II. and III., below the surface. The plants growing in soil containing over 50 per cent. of moisture burned most severely, while those in soil containing less were not affected nearly so much, showing the extent of injury to be proportionate to the amount of soil moisture. Examination of some of the leaves under a microscope showed much variation in the number of stomata. The upper leaf surface of a cucumber plant grown under normal moisture conditions had 27 stomata to the square millimeter, while that of a plant grown in soil containing 10 per cent. of moisture had only 11.

Those who have used cyanide to any extent in greenhouses are well aware that it has a rather narrow range of safety, and that burning will occur at one time and not at another when the conditions are apparently identical. Most fumigating is done after dark, and it is usually customary to first wet down the greenhouse, on the idea that if the house is well filled with moisture, fumigation is more effective, especially when tobacco is used; and by fumigating after dark less injury is supposed to result from burning of the foliage. This latter notion is based on the assumption that the leaf stomata close in darkness, and therefore less gas is absorbed by the foliage, and burning is not likely to occur.

There are numerous factors associated with the burning of foliage by fumigation which are not well understood. The effect of sunlight and atmospheric moisture, etc., on the burning of tomatoes and cucumbers has been studied by Dr. H. T. Fernald, Mr. W. V. Tower and Dr. C. H. Hooker[1] in the entomological greenhouse. They found that sunlight, cloudy weather, moonlight, drops of water remaining on the foliage and too high a moisture content of the atmosphere were all conducive to burning, and that less burning occurred on cloudy nights or clear nights without moonlight. The best results were obtained by fumigating on clear, starlight nights, with little or no moonlight, or on dry, cloudy nights with a temperature range of 55° to 65° F.

Some observations recently made by Mr. S. S. Crossman in our laboratory show among other things that the stomata or breathing pores, as always believed, close quite rapidly when subjected to darkness, and open in the sunlight, and that various gases result in a closing of the stomata. Mr. Crossman did not have an opportunity to finish his work, but Mr. G. H. Chapman, research assistant, intends to continue it the coming year. If the burning of leaves is caused by gases entering the stomata, and if the stomata are closed by gases, then it is not apparent why foliage should burn more severely in the daytime than at night. Some experiments made a few years ago in our laboratory by Mr. H. M. Jennison, on the effects of various gases on transpiration, showed that when plants are subjected to gases transpiration decreases rapidly, but in most of these experiments, as well as in some of our own with illuminating gas, there occurs a secondary rise in the transpiration curve shortly after the first drop. From these experiments it would appear that various gases cause a marked retardation in transpiration at first, followed by a brief but marked acceleration, after which a general retardation in transpiration follows.[2] It is possible that the stomata of the gas-treated plants may open again shortly after being closed by the gas, and finally close again. Observations on this point, however, are not sufficient for us to draw any definite conclusions.

The effect of burning on foliage is varied, in some cases merely the margin of the leaves being burned. Sometimes burning takes the form of numerous small spots on the leaf, and this would appear to prove that burning takes place through the stomata. In other cases burning appears in more or less large, irregular spots scattered over the leaf, which was the case in these experiments. The margins of the leaves of cucumbers at times become injured from excessive transpiration, the thin and apparently less developed tissue farthest from the water supply being most susceptible. From the nature of many of the burnings resulting from fumigants in these experiments, it does not appear that the condition of the stomata has anything to do with the susceptibility to burning, but is due rather to the condition of the tissue. The experiments bear out this conclusion, it being found that the plants grown under conditions calculated to develop a less resistant tissue are the ones which burn most severely, and that any condition which has a tendency to develop immature tissue favors injury from fumigants. Other factors, such as the continued use of too high temperatures, and probably in some cases certain fertilizers and stimulated growth from various causes such as pruning, growing in sterilized soil, electrical stimulation, etc., bring about the formation of tissue susceptible to burning; and while burning may be associated in some cases with the condition of the stomata and with the process of photosynthesis, the development of the cuticle and texture of the tissue in general plays an important part. In plants growing under more or less dense shade Mr. Thomas noticed, as anticipated, that the epidermis was more poorly developed than that of those plants growing under better light conditions, and that the hairs on the leaves of the well-lighted plants were much larger and more numerous than those on the leaves of the poorly lighted plants. Ecologically, hairs are for the purpose of modifying the effect of light and transpiration, but whether their presence has any bearing on susceptibility to burning was not learned. The difference in the number of stomata on the upper surface of the leaves of plants growing under varying moisture conditions is evidently an adaptation to transpiration.

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[1] Twenty-first Ann. Rept., Mass. Agr. Exp. Station, 1909, p. 73; Twenty-second Ann. Rept., Mass. Agr. Exp. Station, 1910, p. 214.

[2] Jumelle found (see Schneider, Bot. Gaz., Vol. XVIII,. p. 57) that sulfuric ether increased transpiration in light and retarded it in darkness, while Schneider found that by this treatment transpiration was retarded under all conditions.

As regards the various factors associated with burning, such as light, atmospheric moisture, temperature, etc., we are in need of more experimental evidence relating to the specific rôle which each factor may play. The experiments of Dr. Fernald and Messrs. Tower and Hooker, already referred to, were not all made at the same time, which unfortunately introduces a varying factor. They observed that drops of water on the foliage caused burning. Burning often results from fungicides remaining in a liquid form for even a brief period on the foliage. Water apparently absorbs hydrocyanic acid gas, since we have found that trout, which are very susceptible to this gas, located in an aquarium outside the compartments in greenhouses being fumigated with this gas, are killed, although goldfish do not seem to be affected.

While these experiments do not throw light on all the factors involved in susceptibility to burning, they do demonstrate that burning by fumigation with hydrocyanic acid gas is induced by a difference in the development of the tissue, whether brought about by inferior light conditions or excessive moisture in the soil, the more poorly developed tissue being more susceptible to burning. Further experiments are being conducted in our laboratory to throw more light on the influence of other factors on burning.

The most important practical feature brought out by these experiments is that fumigation should be done only when the plants are in the right condition. Any expert gardener can determine at a glance whether his plants are developing normally, and under glass he can control the environment to a large extent. Care should be used in fumigating during periods of cloudy weather, as under these conditions the same amount of resistant tissue is not developed. Low night and day temperatures, as well as a decrease in the soil moisture, counteract this to some extent, but the presence of light is the most important factor in developing resistant tissue. Fumigation will cause less injury following bright than cloudy weather, and should not be done for two or three days after a cloudy period, so that the plants will have a chance to harden up their tissue. Plants growing in relatively dry soils are affected to a less degree by fumigation than those in moist soils. The same care and attention should be given to prevent injury from fumigation that is used by lettuce growers to prevent topburn.

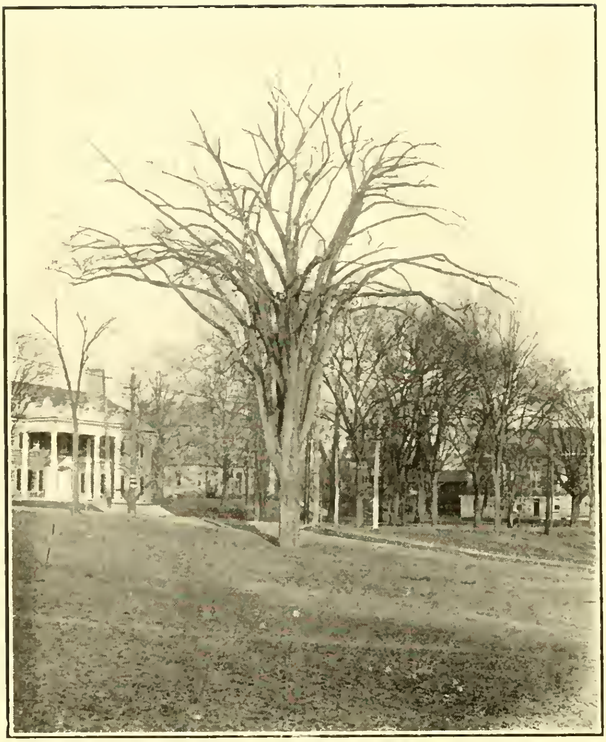

FIG. 3. — Showing elm tree slowly dying, with staghead effect. Note dead, stubby branches at the top.

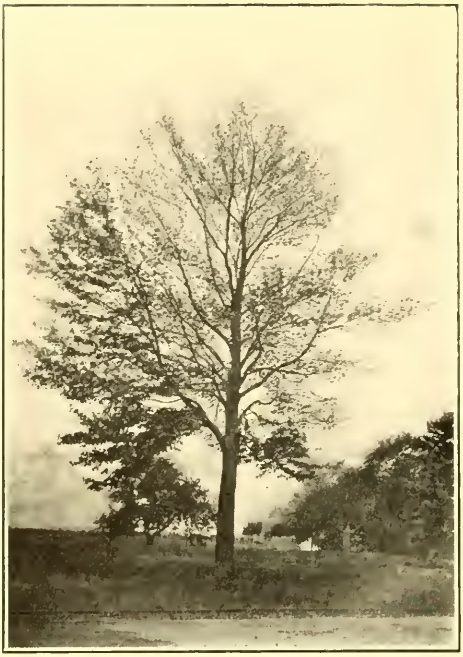

FIG. 1.—Showing red maple, alive, but with inferior foliage at the top.

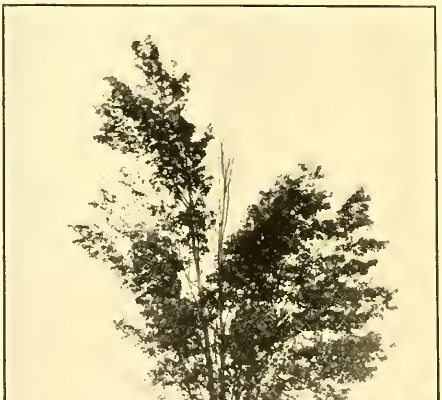

FIG. 2.—Showing maple with staghead effect.

SHADE-TREE TROUBLES.

G. E. STONE.

Staghead and Root Injury.

Many trees since the year 1904 have been showing a characteristic trouble called "staghead." This was particularly noticeable in different degrees of severity on the red maple (*Acer rubrum*) during the summer of 1904, caused by winter killing of roots, etc. In some cases the injury took the form of a scant production of foliage at the top, while in others most of the foliage at the top would not grow to more than one-fourth its natural size (Fig. 1); and in still other cases, and by far the most common, the top of the tree died outright (Fig. 2). In the cases where the foliage was merely thin the trees recovered the following season and have remained in a normal condition since. In others, the foliage at the top would become continually more scant and more limbs affected, until eventually the whole tree would die. Owing to a defective root system a very large number of maples were affected in this way.

During the past two years a large number of trees in the northeastern part of the United States have shown this staghead effect. The trouble appears to have come from the root system, but whether due to winter injury or to the extreme drought which has been common the last five or six years, or to both, is not known at the present time. There are many varieties of shade trees affected in this way at the present time, and this means their ultimate destruction, since those that do not die outright will never recover their tops, and are therefore worthless as specimens of shade trees. This dying back is particularly noticeable on elms, which appear to have been affected at the roots for possibly eight years (Figs. 3 and 4). Owing to the different habits of branching, — the rock maple possessing one main leader, while the elm has a number, — their manner of dying back is different from that of maples. In the latter the most direct channel for the conduction of water is usually through a single leader, while in the elm the water is conducted through several leaders. The center of a maple is therefore affected first, but in the case of the elm the trouble may be noticed in some cases on one side of the tree alone, while in others the whole tree suffers. With some trees the terminal twigs and branches die gradually, it requiring from three to six years for the tree to collapse, while again the tree may die very suddenly. Sometimes a great many of the smaller branches and the remaining branches and twigs are characterized by dense (Fig. 5) tufted foliage. The black oak (*Quercus ellipsoidalis*) and the white oak (*Q. alba*) are affected by winter killing in some sections, and an examination of the roots of numerous trees showed them to be in very bad condition (Fig. 6). A principal feature of the dying back of the oak in some localities is the production of clusters of unusually large and abnormal leaves here and there on the twigs and branches — the tufted foliage already mentioned.

A large number of chestnut trees not affected in any way with chestnut blight have the last three or four years developed staghead. While the symptoms of this dying back are not alike in all cases, they are easily distinguished from those caused by other agents such as gas poisoning, etc. In a majority of cases trees showing this staghead effect, whether from drought or winter killing, die gradually, and even when their death is more or less rapid there are few of the symptoms characteristic of gas poisoning. Trees poisoned by gas usually die quickly and disintegrate rapidly; besides, the diagnostic features to be found in the tissues of trees killed by gas are entirely different. When a tree is affected by gas the poisonous constituents are slowly translocated from one part of the tree to the other, and the symptoms of this type of injury may be easily distinguished from that of other types.

A characteristic feature of trees affected with staghead, more conspicuous in slowly dying trees, may be seen in the increase of the heartwood and decrease of the sapwood. A diminution of the water current in the woody tissue appears to be the cause of this transformation. As a consequence of this dimi-

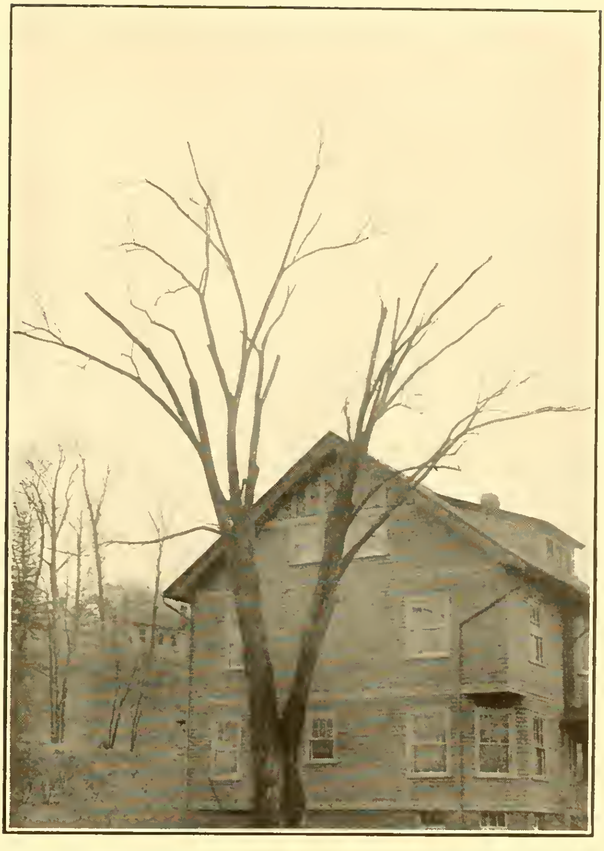

Fig. 4.—Showing elm slowly dying, with staghead effect.

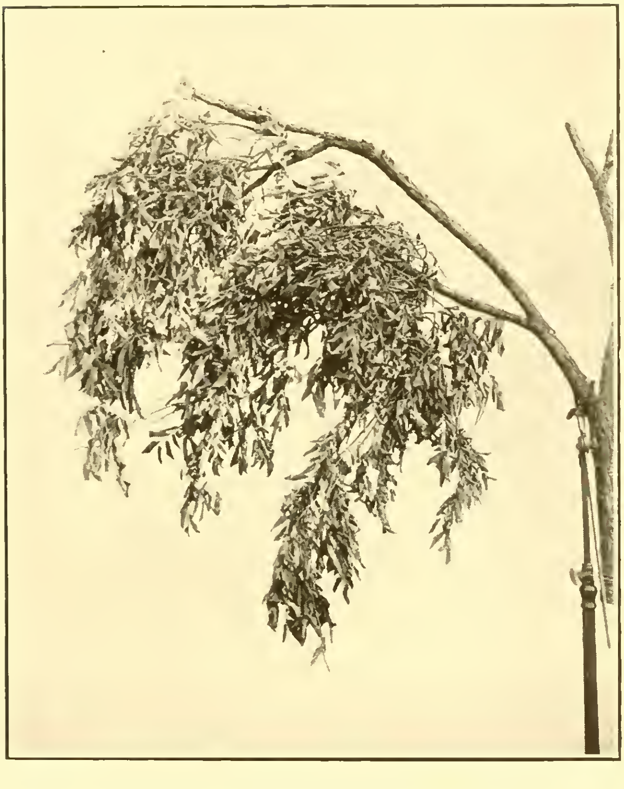

FIG. 5. — Showing elm branch with tufted foliage. A large percentage of the branches on this tree are dead.

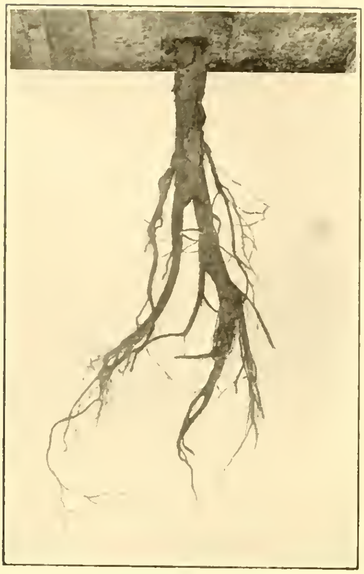

FIG. 6. — Showing winter-killed root from elm tree. Note lack of fine fibrous roots, which have died.

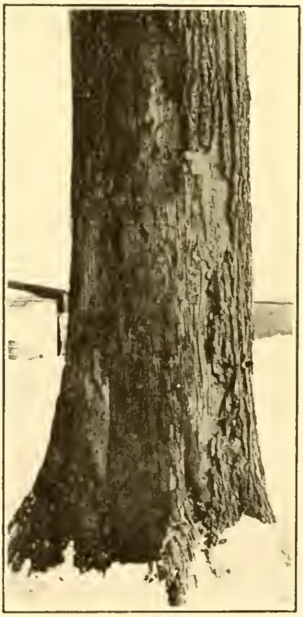

FIG. 7. — Showing elm tree which has lost its outer bark, resulting from injury to cork cambium.

nution the wood of the slowly dying trees is very brittle, and the limbs and branches fall off easily. Old trees reaching the end of their grand period of growth usually show the same characteristics, and for this reason they, too, become dangerous. For many years we have observed the falling of limbs and trees, and have noticed that outside, of course, of tempests, ice storms, etc., a large percentage fall when there is no wind and when the atmosphere is unusually quiet, especially during October and November after the leaves have fallen. The exact cause of this we do not know, although it may be associated with some physical or chemical change in the tissues occurring after defoliation. It is known, however, that water, oils and various chemical substances modify the physical properties of the tissue, and the water contents of a tree at different seasons of the year vary, as shown by Clark,[1] from 25 to 70 per cent., and in severe periods of drought the percentage of water may be very low. That this variation may have some influence here is suggested by the behavior of chemically treated paper containing wood fiber. When wet its tensile strength is increased.

Injury to Cork Cambium.

A great deal of injury to the roots and other parts of trees occurred from the severe cold of the winter of 1903–04. The death of tissue from winter killing is induced by a variety of causes and conditions, and we shall not attempt to discuss them here except to state that any plant, whether indigenous or introduced, is susceptible to winter injury if the conditions are favorable. But it is not always the case that all the living tissues are injured, since winter killing is often local, and even a single tissue may be affected. Following this unusually cold winter many trees died outright, and we found many elms and some sycamores which had lost their outer bark, apparently because of injury to the cork cambium. Sometimes the bark, cortex and phloem were all injured, but in most cases noticed only the outer bark was involved (Fig. 7). This type of injury would not in most cases be noticeable at first, but gradually the dead outer bark which had remained on the tree for some time would peel off in reddish flakes, finally crumbling into dust. We have observed cases in which all the outer bark of large sycamore trees extending to the cortex had peeled off without causing any particular harm.

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[1] Twenty-second Ann. Rept. Sec'y Mass. State Bd. of Agr., 1874, p. 288.

SUN SCALD.

Sun scald is a quite common type of injury affecting various maples and other trees, — the apple in particular, where it is often associated with canker (*Sphæropsis*). White pines, also, when thinned too freely, will sun scald severely on the trunk. Many shade trees in our State show injury from this cause, the trouble being more common in some localities than in others. In one section of a city in the eastern part of the State we found a short time ago more than 60 per cent. of the maples suffering from sun scald. The scars were invariably on the sunny side of the tree, and more commonly on the southwestern side, where the maximum temperature was usually found.

Sun scald does not usually involve the whole trunk of large trees, but in many cases, particularly small maples, the whole tree will suffer. A few years ago on one street in a comparatively short distance, sixteen maples might have been seen which had died from sun scald, and at one time most of our wild cornels (*Cornus circinata*) suffered severely from this trouble, many of them never recovering. The moose maple, a shade plant, seldom scalds in its native habitat but when timber is removed and the sun allowed to enter, it is affected. This tree is undoubtedly the most sensitive of any to sun scald.

Most cases of sun scald are followed by an outbreak of *Nectria cinnabarina*, as is often the case with winter killing, and unripened wood is more susceptible to the trouble than well-ripened wood. The under branches of unpruned apple trees are especially susceptible to sun scald, while the upper branches, which receive the light, are affected the least.

BLEEDING.

A great many trees suffer from bleeding from different types of injury, such as borers, frost cracks, splitting of the trunk and occasionally linemen's spurs. Often trees filled with cement bleed, the exudation causing an unsightly appearance of the bark. Bleeding to excess is very injurious. Sometimes the death of trees from this cause is sudden, and in other cases the tree will linger, gradually dying back at the top, and eventually collapsing. The exuded sap, known as "slimy flux," usually contains a large number of micro-organisms which give the sap a peculiar odor. Elm trees often show a white streak on the bark caused by some injury resulting in bleeding, and maples are also quite often affected, sometimes going into a slow decline, followed by death from bleeding alone. In one instance we observed a maple of fairly good size which had frost cracked so badly that it did not live for more than five or six weeks, the numerous cracks extending from the top to the bottom of the trunk. These injuries are a difficult class to treat, and at present no satisfactory method is known.

Injuries from Snow.

Vegetation is occasionally injured by snow. The leaves of coniferous trees — *Pinus Strobus*, for example — are sometimes affected, and the needles on the lower limbs of small pines which have been covered by snowbanks in the spring turn brown and die. But injury from snow is not very common, and has never been known to cause serious harm.

Earth Fillings.

The remodeling and regrading of streets, lawns, etc., often necessitate filling in around trees. These earth fillings are usually fatal to trees, due no doubt as often to the effects of the earth on the bark as to the lack of air to the roots from the deep covering of the soil. We have seen trees growing on a bank with one side of the root system and part of the trunk covered with soil. Those parts covered with soil gradually died, and finally the whole tree collapsed. The maximum depth of soil around the trunk was not more than 8 inches, but the roots were covered for 18 to 20 inches. The soil used for refilling was of a fine texture, — undoubtedly more injurious than a loose-textured soil would have been. In this case the death of the trees was caused by too close contact of the soil with the bark. When a stone wall is first built around the tree at sufficient distance to allow for future growth, to keep the soil away from the trunk, trees filled in to a height of 5 or 6 feet have been known to survive for many years.

Some trees are undoubtedly more easily injured by earth fillings than others, but building a wall around them to keep the dirt from the trunk, or even the use of cobble stones, brick or coarse gravel close to the trunk, tends to prevent injury. Banking soil for even a few inches around young trees sometimes causes injury. In the case of a young orchard which we observed a few years ago soil was piled up 3 or 4 inches around the trunks of some of the trees for the purpose of protection, but in nearly all instances the tissue underneath was dead, while the trees not treated in this way were all alive.

There are many instances where trees which have been buried partly up the trunk threw out a new root system nearer the surface of the soil. The tree shown in Fig. 8 had been filled in with soil to a depth of 4 feet thirty-five years ago, and in removing the tree it was found that the old stump and roots were all decayed, but the new surface roots had proved sufficient to support the tree.

Exposure of Roots.

Occasional injury occurs to the large roots of trees from regrading and other causes. A few years ago we had occasion to examine a large number of hickory trees (*Carya alba*) located on a country estate which had been injured quite seriously, apparently from sun scald. They had been growing for many years under natural conditions and were fairly vigorous, but during the construction of a large house, and the regrading of the ground, many of the roots — particularly the buttresses — had become exposed. In every case where the soil was taken from the base of the tree and the roots were exposed, the tissue was all sun scalded, but the tissue on the underside of these roots was perfectly normal. In some cases this caused the death of the trees.

It is sometimes possible to expose the larger roots of trees without doing any harm, but at other times sun scald will

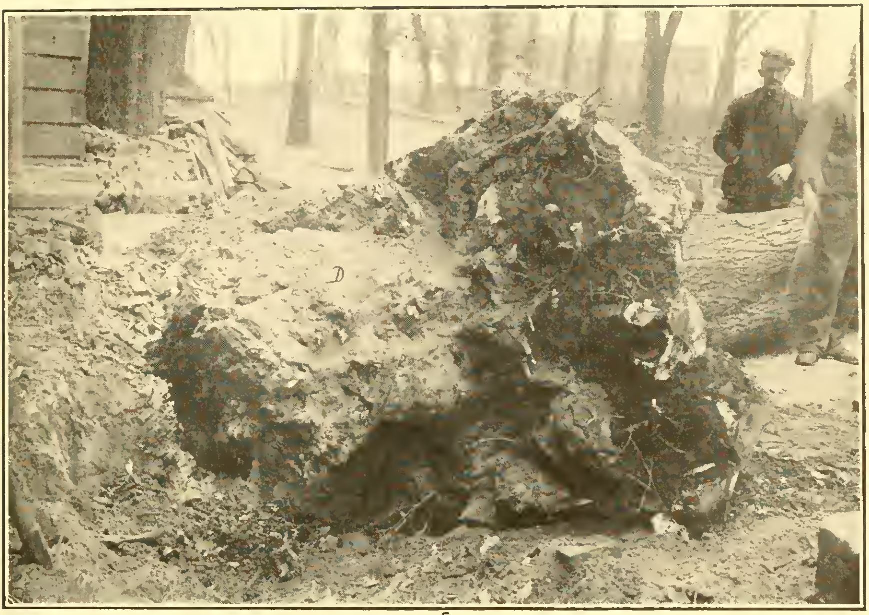

FIG. 8 —Trunk of an elm tree showing old trunk and new formation of roots. Photo from W. F. Gale, City Forester, Springfield, Mass.

result. In cities where the streets are constantly being regraded, the surfaces of the larger roots may often be found exposed, but in perfectly normal condition.

INJURIES FROM VARIOUS TREATMENTS.

We have at different times had occasion to observe injuries to shade trees brought about by various causes, in many cases resulting from treatment applied by careless or ignorant persons. The present widespread treatment of various pests, as might be expected, has made necessary the testing of different remedies, some of which have proved to be more injurious than the pests themselves. These materials have not only been used by careful people trained in the use of different methods for controlling insects and fungi, but by others who are reckless to the point of seeming to delight in taking chances.

Oil. — Many different oils have been used for spraying insect pests, some of which have proved reliable and others injurious. Kerosene oil can be used on some plants under certain conditions without causing injury, while in other cases it will kill them. A few years ago there was placed on the market a spraying device for the mechanical mixing of kerosene and water in different proportions, but when these materials are mixed mechanically they usually separate, and they have been responsible for the death of many trees. The oil soaks into the bark and often reaches the cambium and sapwood, destroying the tissue; and we have seen quite a few shade trees killed by spraying with kerosene and water to exterminate wooley aphis. In some cases every part of the tree touched by the kerosene was injured, while in others the injury was only local, a more commonly noticed condition on thick-bark trees, while the former case was invariably restricted to trees with thin bark. The bark of trees killed by the use of kerosene presents a different appearance and develops usually a different type of fungous flora from the bark of trees dying from other causes; besides, traces of the oil, which remain on the tree for a long time, can be detected by the sense of smell. A fair diagnosis of this type of injury may be made from specimens of the bark, but when there are comparatively slight local injuries it is best to examine the tree *in situ*. Even slight traces of oil may be detected by removing small portions of the outer bark on the sunny side of the tree, the sun's heat causing a slight volatilization and perceptible odor.

Gas oil, a heavy oil used in the manufacture of water gas, is very injurious to trees when used as a spray. A few years ago several hundred shade trees were severely injured in one of our eastern cities by spraying the trunks with this oil to kill clusters of gypsy moth eggs, it being used without any knowledge of its adaptability to this purpose (Fig. 9). The oil quickly soaked into the bark, cortical tissue and cambium, and in some cases extended into the sapwood for one-half to three-fourths of an inch. This injury occurred even on trees with fairly thick bark, killing all the living tissue wherever the oil was applied. While in some instances the trees did not show extensive injury, in others the trunks were 50 to 90 per cent. girdled, and many of the trees died from complete girdling. The most striking feature of this case was the ability of the trees to produce perfect foliage even after serious injury had been incurred. One tree was examined whose trunk was girdled for a height of 15 to 20 feet, but this tree persisted in producing foliage for two years after the bark had fallen off. An explanation of this remarkable case consists in the fact that the heavy oil soaking into the sapwood prevented it from checking or cracking, therefore the supply of water from the roots was uninterrupted. The trees treated were elms, different species of maples, etc. The presence of oil in the sapwood in the cases cited above was of the greatest aid in preventing cracking and in helping to maintain the transpiration current and a full crop of foliage, and this bears out the recommendation that tree wounds should be painted or treated in some way very soon after they are formed to prevent cracking. It is sometimes necessary to scrape the wound before applying the paint.

Ordinary house paint, although a crude enough treatment, has sometimes been used by ignorant persons on smooth-bark trees, with of course resultant injury.

Occasionally commercial oils used for spraying fruit trees for the San José scale cause local injury, and some shade trees have been known to be affected by their use.

Oils and other materials to keep down the dust in roadbeds

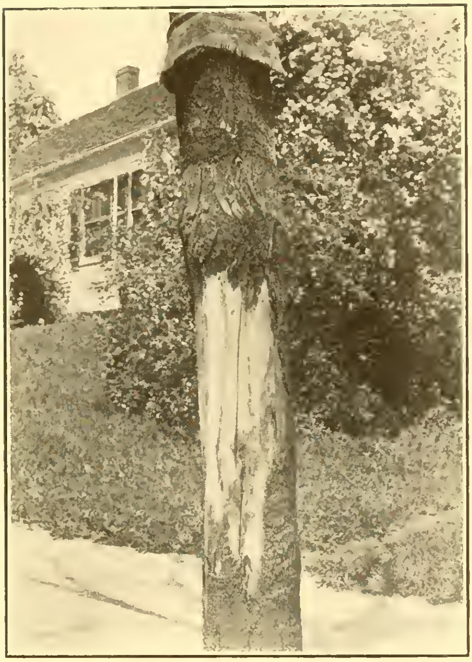

FIG. 9. — Showing effects of spraying heavy oil on trees. The oil penetrated the bark and killed the tissue.

are now much in use, and we have observed some injury from this source, when the trees were located close to the highway and the buttresses of the roots were exposed. The roots are much more susceptible to injury from various causes than are the trunks as they are not so well protected by bark, and when oil sprinkled on a roadbed touches some of the exposed roots it kills the tissue. Particles of dust from oiled roads which sometimes alight on the foliage of trees are said to cause injury, but this type of injury is rare with us. Whether the oil ever extends deeply enough into the roadbeds to reach the root system of trees is not known as yet, but if it does it may cause serious injury. Neither are there specific cases of injury to the roots of trees by the dripping of oil and gasoline from automobiles, although if this leakage were sufficient it might reach the roots and cause injury. Not long ago, however, our attention was called to a tree supposed to have been killed by gasoline leakage from a near-by garage.

Creosote. — This material is used extensively on trees for disinfecting cavities, and mixed with lampblack for painting gypsy moth egg clusters. It does not appear to penetrate to any great extent when combined with lampblack. We have examined a great many trees to discover injuries from its use with no success except in the case of linden roots which had been exposed by regrading, where the underlying tissue was injured. But such instances are rare and the injury purely local in character.

In one case a combination of creosote and naphtha applied to a large number of trees for the destruction of gypsy moth caterpillars appeared to soak into the outer bark, apparently killing the cork cambium, which later resulted in a disintegration of the tissue. Whether these substances did further injury to the tree we were not able to learn.

Coal Tar. — Coal tar is much used for painting wounds and scars caused by pruning, and sometimes injures delicate tissue when first applied. The injury, though, is not serious, as shown by the fact that various saprophytic fungi have been applied over dead, punky wood. Therefore after coal tar has been on for some time it is evidently not injurious to even delicate tissue.

Banding Substances. — A study of the effects of different banding substances has been published in the 1907 report of the Hatch Experiment Station. The writer has since then had an opportunity to study these effects quite extensively. Tanglefoot appears to be the only substance that does not cause injury when applied directly to the bark, *i.e.*, when tarred or other heavy paper is not used. Many laboratory samples of substances resembling tanglefoot have been made up, but in only one instance have any of these materials resembled tanglefoot in practically all its properties; at least, among those which have come to our notice. While the injuries from banding substances have been quite pronounced, practically all of the substances causing injury have now been discarded.

An examination of many trees treated with the so-called tanglefoot has revealed only one case of girdling, and even in this case we were not able to obtain any clue to the manufacturer of the particular material causing the injury. This substance, although resembling tanglefoot, may have been one of its many imitations, some of which are known to cause injury. The only other case of injury from tanglefoot was where it had been applied to the trunk at the same place for a number of years. The oil seemed to penetrate the outer bark to some extent, affecting the texture of the bark; but this injury is not serious, so far as we have observed, and can be prevented by changing the location of the band occasionally. We have never noticed any injury from the use of tanglefoot to the cortical tissue or cambium located just underneath the bark. Our previous experiments show that the most delicate tissue was not injured when it was applied to various plants. But injury was noticed to smooth-bark trees when other banding substances were applied even on tarred paper. Tarred paper alone is capable of injuring the bark of some trees, and the injury mentioned above may have been caused in this way.

Salt. — Salt used on sidewalks, in gutters and on trolley lines in winter has been known to cause injury to the root systems of trees. In one instance we noted injury to several small maples growing near a sidewalk and gutter which had been treated heavily with salt. In one or two other cases where salt had been used extensively on trolley tracks injury to trees was suspected.

Other Injurious Factors. — Arsenate of soda, potassium cyanide and other chemicals are extremely poisonous to trees, and when placed in holes bored in the tree the two first named will soon cause death. Since arsenate of soda is often used as a weed killer, it is recommended that care be taken in applying it around the feeding roots of trees.

A quite common opinion among line-men is to the effect that copper spikes driven into trees will kill them, but a small maple so treated by us a few years ago showed no abnormal symptoms.

The foliage of different trees is often injured by spraying with various fungicides and insecticides. It is well known that plum and peach foliage is quite susceptible to this type of injury, and even the leaves of maples and other trees may be injured by arsenate of lead. The extent of the injury depends not only on the nature of the spraying solution or mixture used, but also on the condition of the foliage sprayed. We have observed injury to maples from the use of 12 pounds of arsenate of lead to 100 gallons of water, and Paris green, owing to its present-day uncertain composition, often burns foliage.

Burning insect nests with torches, although a common practice, is a bad one, and invariably causes injury. Serious harm often results from burning leaves and grass around trees; and the roots of forest trees, which are often close to the ground, are sometimes injured by burning the underbrush.

In conclusion it might be said that in any treatment of trees one should always have before him some definite object; he should leave strictly alone the numerous irrational methods constantly being advocated, and apply to them first the measuring stick of common sense.

EXPERIMENTS RELATING TO THE CONTROL OF POTATO SCAB.

G. E. STONE AND G. H. CHAPMAN.

Early ideas concerning the nature and cause of potato scab in Europe and America varied quite widely, and the history of the study of this disease and the discovery and isolation of the specific organism causing it, together with the discovery of measures for its control, afford a brilliant example of the efficiency of modern pathological investigations. But it is not our intent to give a detailed account of the history of this disease as that has already been done by Dr. J. C. Arthur,[1] Dr. J. E. Humphrey,[2] Dr. R. Thaxter,[3] and particularly Prof. H. L. Bolley,[4] who has given a very full bibliography of European and American investigators.

From the earliest times many theories have been advanced by different observers relative to the cause of potato scab. Some of these early investigators attribute the cause of the disease to different organisms, while others associate the disease with innumerable factors, such as soil, moisture, etc. Dr. J. C. Arthur[5] appears to have been the first American pathologist to study the causes of potato scab. His early experiments were to determine the influence of various factors which some of the older observers regarded as having a bearing on the cause of the disease. In co-operation with Dr. C. A. Goessmann, however, Dr. J. E. Humphrey was working on the disease along the same lines at practically the same time, although his first publication appeared later than that of Dr. Arthur. On Aug. 26, 1890, Prof. H. L. Bolley, then with the Purdue Agricultural Experiment Station, Ind., read a paper before the American Association for the Advancement of Science on potato scab, which was published in the September and October number of "Agricultural Science" the same year, and he established that "(1) the disease is of parasitic origin; that (2) it is for the most part conveyed to the growing crop by infection from the tubers used as seed; that (3) much of the so-called 'smooth seed' is in reality infested with the germs of the disease; and that (4) planting seed tubers free from disease germs gives a crop practically without scab." [1]

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[1] J. C. Arthur, 6th Ann. Rept. N. Y. (Geneva) Agr. Exp. Station, 1888, pp. 344-347.

[2] J. E. Humphrey, 6th Ann. Rept. Mass. Exp. Station, 1888, pp. 131-139; also 7th Ann. Rept., 1889, pp. 214-223, and 8th Ann. Rept., 1890, pp. 216-230.

[3] R. Thaxter, Ann. Rept. Conn. Agr. Exp. Station, 1890, pp. 81-95; also 1891, pp. 153-160.

[4] Agr. Science, 1890, Vol. IV., pp. 243-256; also pp. 277-287.

[5] J. C. Arthur, Bul. 56, Purdue Univ. Agr. Exp. Station, 1895.

His researches and experiments proved to be a great step in advance. While he apparently did not discover the true nature of the organism he paved the way for investigations on the prevention of the disease.[2]

The results of Dr. R. Thaxter's investigations, which were carried on in 1890, were read before the Association of Agricultural Colleges and Experiment Stations November, 1890, and later were published in a report of the Connecticut Experiment Station. His work largely confirmed that of Professor Bolley. He isolated and cultured an organism with which he was able repeatedly to successfully inoculate potatoes and produce the typical scab, although the organism was different from that described by Professor Bolley. It should be noticed that both Professor Bolley and Dr. Thaxter were working on the same lines unknown to each other, and made their results public at nearly the same time, each having arrived at similar conclusions as to the cause of the scab. The organism which Dr. Thaxter isolated was not a bacterium but a low form of fungus possessing more or less indefinite relationships. He later named this, *Oöspora scabies.* Although this organism has been isolated and studied by only a few other pathologists, it is generally recognized that it is the principal if not the only organism associated with the scab. It would not be at all unlikely that the bacterium which Professor Bolley isolated is capable of producing a form of scab; nevertheless, from the viewpoint of treatment and remedies it matters little whether there is one organism or two associated with the disease. In either case remedies are based on the same principle, *i.e.,* the disease is caused by a pathogenic organism and is infectious.

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[1] J. C. Arthur, Bul. 56, Purdue Univ. Agr. Exp. Station, 1895.

[2] Professor Bolley was thoroughly convinced that potato scab was caused by a pathogenic organism, and from the first made use of corrosive sublimate in his experiments. He was unfortunate in having very poor material to work with, and informs me that the soil was badly contaminated with the scab and bacteria. Dr. Thaxter observed the fungus growing on the surface of the potato, but Professor Bolley failed to find this, although he found plenty of bacteria.

Professor Bolley [1] later developed a method for preventing the scab which has proved quite effective, at least under certain conditions. This method consists in soaking the seed potatoes in a solution of corrosive sublimate, 23 ounces to 15 gallons, for a period of one and one-half hours. This is to destroy the germs on the seed potatoes, and when this treatment is applied with such necessary precautions as the avoidance of stable manures, etc., it has proved effective, at least when the organisms are not especially abundant in the soil. Experiments with corrosive sublimate were also carried on for three years by Dr. J. C. Arthur,[2] and in the meantime both Professor Bolley and Dr. Arthur were experimenting with formalin, Professor Bolley [3] as a remedy for the smut of wheat, oats and barley, and Professor Arthur as a remedy for the scab. Professor Arthur [4] later published his experiments with the use of formalin as a preventive of potato scab. He shows that formalin (40 per cent. solution), used at the rate of 8 ounces to 10 gallons of water, is effective and equal to corrosive sublimate, besides possessing fewer disadvantages in handling. Corrosive sublimate and formalin have now been in use for many years as a preventive of potato scab, and both have been the means of greatly reducing the disease. As they are designed to kill the organisms on the surface of the tuber and not those in the soil it is always necessary to use other measures to accompany the treatment with the chemicals. Dr. Thaxter from the first recognized the necessity of using clean seed potatoes and the avoidance of stable manures.

Dr. B. D. Halsted [5] has experimented with various substances for the control of potato scab, and he has reported especially favorable results from the use of flowers of sulfur applied to the soil. He maintains that it not only proved to be the best remedy for the scab but had a wholsome effect on the soil. Dr. Arthur, on the other hand, found sulfur unpromising and discontinued experiments with it. His experience with sulfur was corroborated by Dr. H. J. Wheeler [1] and Mr. G. M. Tucker, who experimented to quite an extent with sulfur and various fertilizers. They found that when sulfur was freely mixed with soil badly contaminated with scab it had no appreciable effect in controlling the disease, and was practically a failure. They found, also, that stable manure of all kinds, wood ashes, air slaked or caustic lime, carbonate of soda, potash, lime and magnesia favored the scab. They obtained a scabless potato with calcium chloride or land plaster (gypsum), and when fertilizers were used without any free lime compounds no scab occurred. They further observed that the marked acidity of the soil or the absence of carbonates was unfavorable to scab. They maintain that when the soil is favorable to the development of scab, or when badly contaminated, the corrosive sublimate treatment is entirely useless as a preventive. The results of Wheeler and Tucker's experiments are in accord with conditions which we have observed in Massachusetts for many years. The presence of carbonates in the soil will increase scab from 2 or 3 per cent. to practically 100 per cent. in a relatively short time, and the use of clean seed, or their treatment with corrosive sublimate or formalin according to the formulas recommended under these conditions, is of little value. On the other hand, when soils are unfavorable for the development of the scab and are only slightly contaminated, formalin and corrosive sublimate are very effective and have been of great value as preventives of this disease.

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[1] H. L. Bolley, Bul. 4, North Dakota Agr. Exp. Station, 1891; also Bul. 9, 1893, pp. 19–95.

[2] J. C. Arthur, Bul. 56, Purdue Univ. Agr. Exp. Station (Ind.), 1895.

[3] H. L. Bolley, Bul. 19, N. D. Agr. Exp. Station, 1895; also Bul. 27, 1897, and Bul. 37, 1899.

[4] J. C. Arthur, Bul. 65, Purdue Univ. Agr. Exp. Station (Ind.), 1897.

[5] B. D. Halsted, Bul. 112, N. J. Agr. Exp. Station, 1895; also Bul. 120, N. J. Agr. Exp. Station, 1897.

Experiments with Various Chemicals for the Prevention of Potato Scab.

In the spring of 1908, as a result of much local complaint relative to potato scab and methods of eradication from infested soil, it was thought that it might be possible to treat the soil with certain chemicals and in this way eradicate the trouble.

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[1] H. J. Wheeler and G. M. Tucker, Bul. 40, R. I. Agr. Exp. Station Rept. 1896, pp. 80–96.

Wheeler and Tucker have made many observations on the influence of fertilizers on potato scab. They found that such substances as common salt, oxalic acid, calcium chloride and land plaster (gypsum) did not increase the scab, and in some instances appeared to lessen it. Various fungicides and chemical substances have been tried by Arthur and others, some of which were applied to the soil and others to the seed tubers. Many of these have been found beneficial in checking the scab, but none appear to be as effective as corrosive sublimate and formaldehyde.

In our experiments arbitrary substances were taken, some of which under proper conditions were known to have a fungicidal action.

It was thought useless to use fertilizers in excess as a means to the end, as it had been shown that fertilizers as a rule have little or no effect on the increase or decrease of the scab in land, with one exception. It was noted repeatedly on experimental plots at the station that where potash was applied in the form of the carbonate the relative amount of scab was always increased.[1]

The experiments described in the following pages were carried on in circular, lined tiles with a diameter of 23 inches, with therefore an area of approximately 424 square inches, or a soil area of a little less than 3 square feet.

In the application of the substances no attempt was made to bring the quantities used to an amount that would make them commercially valuable, and up to the present time this policy has been carried out, as the idea primarily was to find some substance which would be beneficial in the eradication of the scab, and then work the amount down to a commercial scale.

The potatoes used in all the experiments were free from scab, but were all treated with formalin (1–250) to kill any spores of scab fungus which might be present. After the tubers were dried they were planted in the tiles which contained equal amounts of soil known to be badly infected with the scab fungus.

In the experiments carried on in 1908 the substances and amounts used are shown in Table I. Where liquids were used, the amount of water in indicated proportions was added.

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[1] Influence of Various Potash Salts on Potato Scab, 13th Ann. Rept., Mass. Agr. Exp. Station, 1907, pp. 39 and 133.

Where solid substances were used, the substance was mixed thoroughly with the top 4 inches of soil.

In the following table a check tile was used alternately with a treated tile, and as the amount of scab on the potatoes in all the check tiles was practically the same, the checks are omitted: —

TABLE I. — *Plan of Potato Scab Experiments, 1908.*

Pot Number.	SUBSTANCE USED.	Amount used.
1	Formalin, 1-100,	114 cubic centimeters.
3	Formalin, 1-200,	57 cubic centimeters.
5	Formalin, 1-300,	38 cubic centimeters.
7	Formalin, 1-400,	28.5 cubic centimeters.
9	Potassium permanganate, 1-100,	57 grams.
11	Potassium permanganate, 1-300,	38 grams.
13	Potassium permanganate, 1-400,	28.5 grams.
15	Potassium permanganate, 1-500,	23 grams.
17	Sulfuric acid, 1-200,	57 cubic centimeters.
19	Sulfuric acid, 1-400,	28.5 cubic centimeters.
21	Sulfuric acid, 1-600,	19 cubic centimeters.
23	Sulfuric acid, 1-800,	14.25 cubic centimeters.
25	Acid phosphate,	57 grams.
27	Acid phosphate,	38 grams.
29	Acid phosphate,	28.5 grams.

The potatoes were cultivated in the usual way and allowed to mature. When dug the yield was taken of each pot separately, and the relative amount of scab as compared with the corresponding check tile, but in most cases the yield and amount of scab present closely approximated the check, so nothing of value was obtained from this experiment, as a whole. It was noted, however, that the tiles treated with formaldehyde or formalin were somewhat freer from scab individually; also in the case of the permanganate very little yield was obtained, but the usual amount of scab was present. The sulfuric acid treatment showed possible beneficial effects, but the yield was so small that no accurate comparison could be made.

The experiments, on the whole, were very unsatisfactory, and no deductions of any importance could be made.

The experiments of the season of 1909 were planned in the same manner, but owing to other causes over which we had no control the crop was lost before the examination could be made.

In 1910 the experiment as planned and carried out was as follows: —

TABLE II. — *Plan of Potato Scab Experiments, 1910.*

Pot Number.	SUBSTANCE USED.	Amount used.
1	Formalin, 1-100,	114 cubic centimeters.
3	Formalin, 1-200,	57 cubic centimeters.
5	Formalin, 1-300,	38 cubic centimeters.
7	Formalin, 1-400,	28.5 cubic centimeters.
9	Potassium permanganate, 1-100,	57 grams.
11	Potassium permanganate, 1-300,	38 grams.
13	Potassium permanganate, 1-400,	28.5 grams.
15	Potassium permanganate, 1-500,	23 grams.
17	Sulfuric acid, 1-200,	57 cubic centimeters.
19	Sulfuric acid, 1-400,	28.5 cubic centimeters.
21	Sulfuric acid, 1-600,	19 cubic centimeters.
23	Sulfuric acid, 1-800,	14.2 cubic centimeters.
25	Sulfur,	50 grams.
27	Sulfur,	100 grams.
29	Sulfur,	200 grams.

Upon examination it was found that the check pots were practically all scabby. This was taken as a basis of 100 per cent. scab, and the results from the various treatments estimated in relation to this basis.

Pots Nos. 1, 3, 5 and 7, which were treated with formalin, showed the presence of scab as follows: in pot No. 1 the potatoes had only 10 per cent. scab, as against 30 per cent for pot No. 3, 24 per cent. for pot No. 5, and 70 per cent. for pot No. 7.

In the pots treated with potassium permanganate no yield was obtained except in one case and one check, and here the potatoes were about 50 per cent. scabby in both cases.

In the sulfuric acid treatment no yields of potatoes were obtained except in the check tile, and they averaged 60 per cent. scab.

In the sulfur treatment the treated pots in general showed a slight gain over the untreated or check pots, but not enough to warrant definite favorable conclusions being drawn.

The plans for the experiments in the season of 1911 were changed somewhat, and other chemicals substituted for some that were previously used. This was the result of the non-action or the negative results obtained from some of the substances used. The whole method of choice of substances was of course haphazard, as no foundation for the use of some was warranted.

In 1911 the chemicals used were as follows, and the only old one to be used was formalin. Table III. gives the plan of the year's experiments: —

TABLE III. — *Plan of Potato Scab Experiments, 1911.*

Pot Number.	SUBSTANCE USED.	Amount used.
1	Steam-sterilized,	– –
3	Steam-sterilized,	– –
5	Steam-sterilized,	– –
6	Steam-sterilized,	– –
7	By-product A,	5 grams (dry).
9	By-product A,	10 grams (dry).
10	By-product A,	10 grams (wet).
12	By-product A,	15 grams (dry).
13	By-product A,	25 grams (dry).
15	By-product A,	40 grams (dry).
16	K permanganate-formalin,	100 cubic centimeters, 6 grams.
18	K permanganate-formalin,	25 cubic centimeters, 10 grams.
19	K permanganate-formalin,	40 cubic centimeters, 16 grams.
21	K permanganate-formalin,	60 cubic centimeters, 24 grams.
22	Copper sulfate, 1-1,000,	– –
24	Copper sulfate (1 gallon), 1-10,000,	– –
26	Carbon bisulfid,	15 cubic centimeters.
27	Carbon bisulfid,	25 cubic centimeters.
29	Carbon bisulfid,	40 cubic centimeters.

In the first series, that of the steam-sterilized, it is noticed that a fair yield of potatoes was obtained, and the amount of scab on the check and treated tiles was as follows: —

	Per Cent Scab.		Per Cent Scab.
Check,	40	Steam-sterilized soil,	30
Check,	18	Steam-sterilized soil,	41
Check,	30	Steam-sterilized soil,	23
Average,	29	Average,	31

These results surely do not show much benefit from sterilization, and on the whole the amount of scab seemed to increase with the sterilization. The reason for this is not apparent, but may be explained in different ways. In all probability sterilizing the soil in open boxes by heating the soil to 210° or 212° F. was not sufficient to kill the germs of scab. It seems hardly probable that if the organisms had been killed by sterilizing, the soil in the pots could have been contaminated to this extent, or that the seed after being treated with formaldehyde could have been the cause of this.

In the second series a manufacturer's by-product was used, which for the present we will call by-product A. This was applied in different amounts and scattered in the soil both in the powder form and as a paste mixed with water. The three checks averaged 44 per cent. scab, and the treated tiles averaged 30 per cent. scab, with the lowest amount of scab present in the tile treated with the smallest amount of the by-product A. On the whole, this substance seemed to have some beneficial action, although apparently there were discrepancies in the comparative amounts of scab present in relation to the amounts of the substance used.

The next series, made up of gaseous formaldehyde treatment by the reaction of potassium permanganate on formaldehyde, gave no results except in one or two instances, and then the yield was very small and in some cases none at all.

The series of tiles treated with copper sulfate showed that this substance might have a beneficial action in strengths up to 1–10,000, but there was the same amount of scab on the tile treated with copper sulfate, 1–1,000, as there was on the checks.

The yield was small, however, both on the treated tiles and the checks.

The series treated with carbon bisulfid showed some results, the check tiles averaging 50 per cent. scab and the treated tiles showing an average of 20 per cent.

It can be seen that this year's results are showing some improvement over those of preceding years, and by elimination only the most useful compounds are to be used hereafter, with perhaps one or two additions.

TABLE IV. — *Plan of Potato Scab Experiments, 1912.*[1]

Pot Number.	SUBSTANCE USED.	Amount used.
1	By-product A,	100 grams (dry).
2	By-product A,	300 grams (dry).
3	By-product A,	500 grams (dry).
5	By-product A,	100 grams (wet).
6	By-product A,	200 grams (wet).
7	By-product A,	300 grams (wet).
9	Sulfur,	50 grams (wet).
10	Sulfur,	100 grams.
11	Sulfur,	200 grams.
13	Naphthalene,	50 grams.
16	Steam-sterilized,	– –
17	Steam-sterilized,	– –
18	Steam-sterilized,	– –
20	Formalin, 1-100,	– –
21	Formalin, 1-200,	– –
22	Formalin, 1-300,	– –
23	Formalin, 1-400,	– –
25	Carbon bisulfid,	15 cubic centimeters.
26	Carbon bisulfid,	25 cubic centimeters.
27	Carbon bisulfid,	40 cubic centimeters.
29	Nicine,	100 grams.
30	Nicine,	200 grams.

[1] Numbers omitted were used as check tile. Potatoes treated exactly as in preceding experiments.

In 1912 the experiments were carried on in a similar manner, but for the most part chemical solids were used, with the exception of the formalin treatment, which remained the same as the preceding years.

The by-product A treatment showed good results, especially when applied dry in 500-gram amounts to the pot area. Even in smaller quantities a decided benefit seemed to be obtained, as can be seen from the following summary: —

Substance used.	Amount used, Dry (Grams).	Per Cent.	Amount used, Wet (Grams).	Per Cent.
By-product A,	100	90	100	50
By-product A,	300	40	200	60
By-product A,	500	2	300	50
Check,	–	90	–	75

Apparently this substance has a good effect. The yield of tubers was in all cases good. If the substance were applied at this rate (500 grams to 3 square feet) it would mean about 7 tons to the acre, but it may be shown that a smaller quantity would be sufficient. Much more work is necessary before any definite opinion can be advanced as to the actual worth of the substance.

The sulfur treatment showed slightly beneficial results, the different tiles and check showing the scab present in the following amounts: —

Sulfur, 50 grams,	70 per cent. scab.
Sulfur, 100 grams,	50 per cent. scab.
Sulfur, 200 grams,	60 per cent. scab.
Check,	85 per cent. scab.

The yield of tubers was good in the case of the sulfur treatment.

The naphthalene treatment showed no results, with very little yield of tubers.

The steam-sterilized tiles, sterilized to a depth of 6 inches, and corresponding check showed scab present in the following amounts: —

Steam-sterilized soil (*a*),	60 per cent. scab.
Steam-sterilized soil (*b*),	40 per cent. scab.
Steam-sterilized soil (*c*),	30 per cent. scab.
Check,	60 per cent. scab.

The yield of tubers was good in all cases.

The formalin treatment gave varying results, and when used in quantities sufficient to do good would be probably impractical. The results with formalin were as follows: —

Formalin 1–100,	30 per cent. scab.
Formalin 1–200,	40 per cent. scab.
Formalin 1–300,	70 per cent. scab.
Formalin 1–400,	70 per cent. scab.
Check,	75 per cent. scab.

The yield was only fair in these tiles.

The carbon bisulfid treatment gave negative results, as may be seen from the following: —

Carbon bisulfid, 15 cubic centimeters, fair yield, 80 per cent. scab.
Carbon bisulfid, 25 cubic centimeters, poor yield, 3 per cent. scab.
Carbon bisulfid, 40 cubic centimeters, no yield.

The Nicine treatment gave no results that could be interpreted as either beneficial or otherwise.

The experiments for 1913 will be planned from an economic point of view, and if possible the same experiments will be carried out for a series of years, and plots used in addition to the tiles.

In summarizing the results of experiments with potato scab it will be noticed that many of the substances used had little effect in preventing scab, while others seemed to possess some value. Steaming the soil the second year was done somewhat more thoroughly than the first year, but the results, on the whole, were similar, *i.e.*, in all the sterilized plots, 1911–12, there was little evidence of reduction of the scab. Steaming under pressure or for prolonged periods under no pressure would determine once for all whether the scab germs are unusually resistant to heat. The heated soil, however, proved to be beneficial to the crop, as the yield was good under this treatment.

The best yield in 1912 was given by by-product A in dry form, followed by the sulfur treatment, and the by-product A wet treatment and steam heating. The most satisfactory treatment from the yield point of view as well as that of treatment was by-product A, the dry mixture proving superior to the wet. Our experiments with this substance also indicate that any beneficial results from its use are carried over into the next season, since in those plots in which this substance was employed in 1911 the results were noticeable in 1912. The crop obtained by the use of by-product A at the rate of 500 grams to 3 square feet of surface, consisted of the cleanest tubers we have ever observed in a soil which was badly contaminated with scab, and, furthermore, it does not appear in the least to affect the growth or yield (see Fig. 1). The substance appears to act slowly and continuously as a germicide, and may prove even more efficient in the control of other fungi.

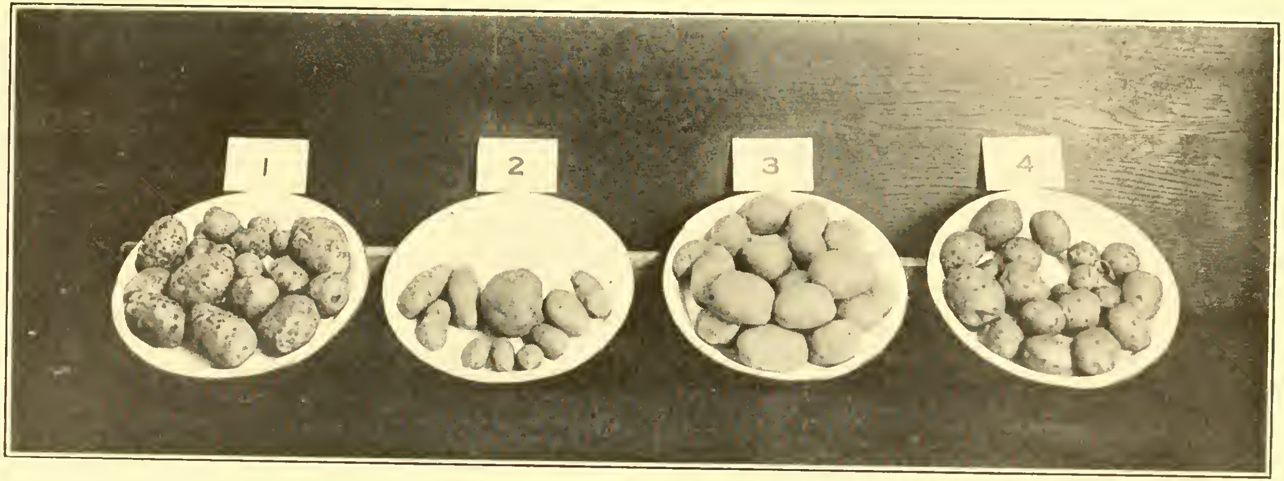

FIG. 1.—Showing treatment of potato scab. All tubers treated with formaldehyde before planting. No. 1, treated with 100 grams of by product A; No. 2, treated with 300 grams of by product A; No. 3, treated with 500 grams of by-product A; No. 4, treated with check.

AN OUTLINE OF SOME OF THE TOPICS COVERED BY THE DEPARTMENT OF VEGETABLE PHYSIOLOGY AND PATHOLOGY SINCE ITS INCEPTION.

G. E. STONE.

The department of vegetable physiology was established in the State Experiment Station in 1888, and Dr. James E. Humphrey, under the supervision of Dr. C. A. Goessmann, carried on investigations from November, 1888, to 1892, when he resigned. A bibliography of the more important papers published by the department follows: —

Sixth annual report of the State Experiment Station, 1888: potato scab.

Seventh report, 1889: general account of fungi; potato scab; fungous diseases on the station farm; notes on material referred to the department.

Eighth report, 1890: black knot of plum; mildew of cucumbers; brown rot of stone fruits; potato scab; notes on various diseases.

Ninth report, 1891: rotting of lettuce; powdery mildew of the cucumber; various diseases; preventive treatment.

Tenth report, 1892: diseases of the cucumber plant and violet diseases: the black knot of the plum and cherry; grain rusts; various diseases: treatment for powdery mildew. (From 1892, when Dr. Humphrey resigned, until 1895, the pathological work was temporarily discontinued, but in 1895 the department of vegetable physiology and pathology was established and the work has been continued by the writer since that time.)

Eighth annual report of the Hatch Experiment Station, 1895: this contains mainly an outline of work, and brief references to some experiment topics.

Ninth report, 1896: nature of plant diseases; a bacterial disease of the cultivated strawberry (*Micrococcus sp.?*); stem rot of the cultivated aster; leaf spot of decorative plants; leaf spot of Ficus elastica (*Leptostromella elastica* Ell. & Ev.); a leaf spot disease (*Graphiola Phoenicis* Poit) of the date and similar palms; a leaf spot of the begonia;

a so-called black spot disease of the rose (*Pilobolus crystallinus* Tode); a leaf blight or anthracnose of the cucumber (*Colletotrichum Lagenarium* (Pass.) Ell. & Hals.); an unusual outbreak of two rusts,—asparagus rust (*Puccinia asparagi* D. C.) and a late rust of the blackberry (*Chrysomyxa albida* Kühn.); the tomato mildew (*Cladosporium fulvum* Cke.); a chrysanthemum rust; "drop" of lettuce (*Sclerotinia Libertiana* Fckl.); wilt of maple leaves; topburn of lettuce.

Tenth report, 1897: the causes of the failure of the potato crop of 1897; the "drop" of lettuce; the asparagus rust (*Puccinia asparagi* D. C.); the fire blight (*Bacillus amylovorus* (Burr.) DeToni); quince rust (*Gymnosporangium clavipes* C. & P.); brown rot of stone fruits (*Monilia fructigena* Pers.); the chrysanthemum rust (*Puccinia Tanaceti* S.); some leaf blights of native trees; a leaf blight of the sycamore or buttonwood (*Glœosporium nervisequum* (Fckl.) Sacc.); a leaf blight of the butternut (*Glœosporium Juglandis* (Lib.) Mont.); a leaf spot of the chestnut (*Septoria ochroleuca* B. & C.); a leaf spot of the wild black cherry (*Septoria cerasina* Pk.)

Eleventh report, 1898: scope of work; black spot of the maple (*Rhytisma acerinum* (P.) Fr.); oak leaf blight (*Glœosporium nervisequum* (Fckl.) Sacc.); walnut leaf blight (*Glœosporium Juglandis* (Lib.) Mont.); a muskmelon disease; rotting of cabbage; further considerations in regard to the drop in lettuce; the chrysanthemum rust; a new pansy disease; seasonal peculiarities of certain shade trees; overfeeding of plants; the bronzing of rose leaves; cucumber wilt; some difficulties which city shade trees have to contend with.

Twelfth annual report, 1899: aster diseases; the bacterial cucumber wilt; a geranium disease; muskmelon failures; the maple leaf blight (*Phyllosticta acericola* C. & E.); the chrysanthemum rust; some experiments in growing violets in sterilized soil; the relationship existing between the asparagus rust and the physical properties of the soil.

Thirteenth report, 1900: aster diseases: nematode worms; cucumber mildew (*Plasmopara Cubensis* B. & C.); Russian thistle in Massachusetts; influence of chemical solutions upon the germination of seeds.

Fourteenth report, 1901: the dying of cut-leaved birches; the present status of chrysanthemum rust in Massachusetts; the effects of desiccation on soil; melon failures; stem rots and wilt diseases; the present status of the asparagus rust in Massachusetts; sterilization of soil in greenhouses for fungous diseases.

Fifteenth report, 1902: peach leaf curl (*Exoascus deformans* (Berk.) Fckl.); apple leaf spot; sycamore blight (*Glœosporium nervisequum* (Fckl.) Sacc.); strawberry root rot; apple scab (*Fusicladium dendriticum* (Wallr.) Fckl.); cucumber wilt; sweet pea troubles; aster diseases; potato blight (*Phytophthora infestans* (Mont.) DeBarry); cucumber and melon diseases; asparagus rust (*Puccinia asparagi* D. C.); chrysanthemum rust (*Puccinia Chrysanthemi* Roze); the cucumber mildew (*Plasmopara Cubensis* (B. & C.) Humphrey) in Massachusetts; the muskmelon blight; an apple leaf spot; a strawberry disease; plum "yellows;" spraying of linden and elm trees for leaf spot; crops under tent cloth; experiments in heating soils; influence of sterilized soil on seed germination.

Sixteenth report, 1903: influence of current electricity on plant growth; influence of atmospheric electrical potential on plants.

Seventeenth report, 1904: crops as related to weather conditions; testing of seed; the practice of soil sterilization; influence of electrical potential on the growth of plants; some important literature relating to disease of crops not generally believed to be caused by fungi or insects.

Eighteenth report, 1905: downy mildew of tomato (*Phytophthora infestans* DBy.); potato rot (*Phytophthora infestans* DBy.); cucumber and melon blight; sun scald; burning of conifers and evergreens; winter killing; relation between soil aeration and germination and growth; comparison of sterilized loam and subsoil; influence of soil sterilization on seed germination; an application of the copper sulfate treatment; a comparison of the numbers of bacteria in sterilized and unsterilized soils.

Nineteenth report, 1906: outline of work; seed work; prevalence of fungi, etc.; bacterial disease of cucumbers; bacterial disease of lettuce; bacteriosis of geraniums; tobacco troubles; monilia on peach stem; the lime and sulfur mixture as a fungicide; potato-spraying experiments; banding substances for trees; effects of escaping illuminating gas on trees; germination and growth in soils of different texture; texture of Massachusetts soils.

Twentieth report, 1907: outline of the year's work; seed work; seasonal peculiarities; sun scald; sun scorch premature defoliation of trees; asparagus rust; asparagus Fusarium; peony troubles; potato diseases; experiments with fungicides; influence of various potash salts on potato scab (*Oöspora scabies* Thaxter); investigations relating to mosaic disease; some factors which underlie susceptibility and immunity to disease.

Twenty-first report, 1908: brief notes on the weeds of Massachusetts; results of seed separation; examination of onion seeds for fungous spores; bacterial rot of cabbage and cauliflower; crown gall; the preservation of maple syrup; onion rot; onion smut; a disease of the radish; celery crown rot; eel worms (*Heterodera radicicola* (Greef.) Müll.) on lettuce; influence of water on eel worms; influence of lime on eel worms; effects of chemicals on vegetation; substances and methods used in exterminating weeds; seed work; common weed seeds in grass seed and cattle foods.

Twenty-second report, 1909: diseases more or less common to crops during the year; shade tree troubles; malnutrition; calico or mosaic disease of cucumber and melon; notes on the occurrence of fungous spores on onion seed; spraying injuries; control of certain greenhouse diseases; damping-off fungi; spraying experiments with calcium benzoate; seed purity work, 1909, seed germination and separation; sun scorch on the pine.

Twenty-third report, 1910: diseases more or less common during the year; seed work, 1910; an outbreak of rusts; sweet pea troubles; a spinach disease new to Massachusetts; condition of fruit trees in general; Fusarium disease of cucumbers and other plants; crown gall; chestnut disease (*Diaporthe parasitica* Murrill); shade tree troubles; the spraying of trees; a new type of spray nozzle; the clogging of drain tile by roots; experiments relating to the prevention of the clogging of drain tile by roots; abnormalities of stump growths; peach and plum troubles.

Twenty-fourth report, 1911: diseases more or less common during the year; seed work for the year 1911; do we need a seed law in Massachusetts; rust on Vinca; bronzing of maple leaves; a notable elm tree; frost cracks; some observations on the growth of elm trees; coarse nozzle versus mist nozzle spraying; a new method for the approximate mechanical analysis of soils; the present status of soil sterilization; influence of soil decoctions from sterilized and unsterilized soils upon bacterial growth; the effects of positive and negative electrical charges on seeds and seedlings; electrical resistance of trees; experiments with rose soils.

List of Bulletins issued by the Department of Vegetable Physiology and Pathology.[1]

Electro-Germination, Asa S. Kinney, Bul. No. 43, 1897.
Nematode Worms, G. E. Stone, R. E. Smith, Bul. No. 55, 1898.
Asparagus Rust, G. E. Stone, R. E. Smith, Bul. No. 61, 1899.
Rotting of Greenhouse Lettuce, G. E. Stone, R. E. Smith, Bul. No. 69, 1900.
Growing China Asters, R. E. Smith, Bul. No. 79, 1902.
Cucumbers under Glass, G. E. Stone, Bul. No. 87, 1903.
Fungicides and Insecticides,[2] G. E. Stone, H. T. Fernald, S. T. Maynard, Bul. No. 80, 1902.
Injuries to Shade Trees from Electricity, G. E. Stone, Bul. No. 91, 1903.
Fungicides and Insecticides,[2] G. E. Stone, H. T. Fernald, F. A. Waugh, Bul. No. 96, 1904.
Tomatoes under Glass, G. E. Stone, Bul. No. 105, 1905.
Blossom End Rot of Tomatoes, Elizabeth H. Smith, Tech. Bul. No. 3, 1907.
Seed Separation and Germination, G. E. Stone, Bul. No. 121, 1908.

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[1] These bulletins are no longer available for distribution by the Agricultural Experiment Station, but may be found in any public library within the State.

[2] Issued in co-operation with other departments.

Fungicides and Insecticides,[1] G. E. Stone, H. T. Fernald, Bul. No. 123, 1908.

Shade Trees,[2] E. A. Start, G. E. Stone, H. T. Fernald, Bul. No. 125, 1908.

Control of Onion Smut, G. E. Stone, Cir. No. 21, 1909.

Lime and Sulfur, G. E. Stone, Cir. No. 31, 1911.

Tomato Diseases, G. E. Stone, Bul. No. 138, 1911.

Microscopic Identification of Cattle Feeds, G. H. Chapman, Bul. No. 141, 1912.

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[1] Issued in co-operation with other departments.

[2] Issued in co-operation with the Massachusetts Forestry Association.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

This report is intended to give an outline of the work in progress by this department during the year ending Dec. 1, 1912.

1. Work of the Research Section.

(*a*) Work on the chemistry of insecticides undertaken in co-operation with the department of entomology has been largely completed, and a somewhat comprehensive paper on the subject was published in the twenty-fourth report. A paper on the chemistry of calcium arsenite was also presented by Mr. Holland to the International Congress of Applied Chemistry in September, 1912. Some additional work will be required for several years in testing the purity of the insecticides employed each year in spraying.

A reasonably satisfactory method has been developed for the quantitative determination of the insoluble fatty acids in butter fat. It is now being applied in the analysis of fat produced by cows at the beginning and end of lactation, and of that yielded by fat and thin cows at the beginning of lactation. The objection to the method is the length of time required for its completion. Another method is under consideration which, it is hoped, will yield equally good results in much less time.

The subject of the digestion depression produced by molasses has been further studied by noting its peristaltic action on the intestines. The observations confirmed those previously made, indicating it to be without noticeable effect.

(*b*) Mr. Morse has made distinct progress in his study of the effect of fertilizers upon asparagus. Phosphoric acid in the ash of the roots was not changed either by the absence or by varying the amounts of phosphate applied to the soil. Potassium oxide in the ash varied with the amounts of potash applied to the soil. Roots collected in the summer of 1911, at the close of cutting for market, showed no apparent exhaustion of nitrogen in them by withholding nitrate of soda until midsummer. Sugar was, however, somewhat depressed by the absence of a spring dressing of nitrate of soda. On the other hand, mature tops collected in October, 1911, gave results showing a small but persistent excess of nitrogen in samples from plots top-dressed with nitrate in the spring.

In case of the plant food requirements of the cranberry, the time has been devoted largely to observations to determine the probable amount of plant food which may be lost in the ditches as well as that which may rise through the peat and sand as the water rises and falls with the changes in rainfall, and the use of water for irrigation and flooding. The total amount added to the irrigation tiles during the summer of 1912 was equivalent to 190,000 gallons per acre. This should, theoretically, carry with it into the sand in which the roots grow some 53 pounds of nitrogen, 30 pounds of phosphoric acid and 85 pounds of potash per acre. Other studies are in progress.

A study of the action of sulfate of ammonia on several of the experiment station plots is in progress and considerable data are being accumulated which, it is hoped, will throw some light upon this perplexing problem.

(*c*) In addition to the above fundamental problems, Dr. Lindsey has continued his studies on the digestibility of cattle feeds, including cottonseed feed meal, cocoanut meal, flax and wheat screenings, flax shives and cocoa shells. An experiment concerning the value of alfalfa hay in milk production has also been completed, and observations are still in progress concerning milk substitutes for rearing dairy calves.

2. Report of the Fertilizer Section.

Mr. Haskins reports as follows: —

Although the principal work of the fertilizer division has been confined to the inspection of commercial fertilizers, yet during the winter months considerable work was accomplished along other lines. The time available was partly devoted to completing the ash analysis of asparagus roots, this being a continuation of work begun during 1911 in conjunction with fertilizer experiments with asparagus. The ash analysis of tobacco stalks preserved under different conditions has been made for the purpose of showing the variation in composition and of emphasizing the importance of conserving all of the plant food which is furnished by this class of material. The analysis of 14 samples of soil taken from different localities and at different depths has been made to show the tendency of potash to accumulate in the subsoil to a depth of from 3 to 5 feet. This work was undertaken for the purpose of confirming results of analysis of subsoils on field A, which showed a remarkable accumulation of potash. Some time has been given to co-operative work with the American Association of Official Agricultural Chemists, particularly with reference to the study of new and improved methods for the determination of nitrogen, phosphoric acid and potash. The writer has served the association for the past two years as referee on phosphoric acid. Considerable preliminary work has been done in preparation for vegetation experiments on fertilizers to be conducted during 1913. Free examination of refuse by-products, fertilizers and soils has been made for farmers and farmers' organizations as in the past; a more detailed account of this work will be found on a subsequent page.

A larger number of commercial fertilizers has been registered, collected and analyzed during the season than for any previous year. The following summaries will give a fair idea of the work involved and will show the condition of the fertilizer trade for the year: —

(*a*) Fertilizers registered.
(*b*) Fertilizers collected.
(*c*) Fertilizers analyzed.
(*d*) Trade values of fertilizing ingredients.
(*e*) Raw products and chemicals.
    (1) Materials furnishing nitrogen.
    (2) Materials furnishing potash.
    (3) Materials furnishing phosphoric acid.

(*f*) Mixed complete fertilizers.
  (1) Grades of fertilizer.
  (2) Summary of analyses and guarantees.
  (3) Quality of plant food.
(*g*) Ground rock, mineral fertilizer or stonemeal.
(*h*) Lime compounds.
(*i*) Free analyses of by-products, fertilizers and soils.

(*a*) *Fertilizers registered.*

Ninety-seven manufacturers, importers and dealers, including the various branches of the trusts, have secured certificates for the sale of 509 different brands of fertilizer, agricultural chemicals, raw products and agricultural lime in the Massachusetts markets. This is 17 more than were registered during the previous year. They may be classed as follows: —

Complete fertilizers,	328
Fertilizers furnishing phosphoric acid and potash,	9
Ground bone, tankage and dry ground fish,	55
Chemicals and organic nitrogen compounds,	91
Agricultural limes,	26
	509

(*b*) *Fertilizers collected.*

An effort has been made to procure a representative sample of every brand of fertilizer and lime which has been registered in Massachusetts, and with few exceptions the effort has been successful. During the early part of April, arrangements were made, upon request, to sample carloads of cottonseed meal, wood ashes, fertilizers and chemicals, these earlier shipments being materials which were purchased for private use by some of the larger consumers. Although this practice has made it necessary to make a much larger number of analyses than formerly, yet it has some good features as it insures the inspection of a larger tonnage than would otherwise be possible, besides furnishing the large consumer an analysis of his particular shipment. Large shipments of many private formulas have been sampled upon request.

The inspectors have, during the year, sampled about 5,600 tons of fertilizer of all kinds, and in doing this have drawn from over 15,000 bags. They visited 138 towns, called upon 329 different agents, and drew 1,180 samples representing 527 distinct brands; this is 117 more samples, representing 45 more brands, than were taken during the previous year.

(*c*) *Fertilizers analyzed.*

Seven hundred and two analyses have been made during the year's inspection; they may be grouped as follows: —

Complete fertilizers,	431
Fertilizers furnishing phosphoric acid and potash, such as ashes,	16
Ground bone, tankage and fish,	68
Nitrogen compounds, both organic and mineral,	87
Potash compounds,	42
Phosphoric acid compounds,	33
Lime compounds,	25
	702

(*d*) *Trade Values of Fertilizing Ingredients.*

At a meeting of representatives of the experiment stations of New England, New York and New Jersey, held during the first week of March, 1912, the following table of trade values was adopted. The trade values represent the average cash cost per pound at retail of nitrogen, potash and phosphoric acid as furnished by chemicals and standard unmixed fertilizing material in the principal markets in New York and New England. The data which are used in obtaining these values are the average wholesale quotations of chemicals and raw materials as found in commercial publications from Sept. 1, 1911, to March 1, 1912, plus about 20 per cent.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals for 1911 and 1912.

	Cents per Pound.	
	1911.	1912.
Nitrogen: —		
In ammonia salts,	16.00	16.50
In nitrates,	16.00	16.50
Organic nitrogen in dry and fine ground fish, meat and blood,	23.00	22.00
Organic nitrogen in fine [1] bone, tankage and mixed fertilizers,	20.00	19.00
Organic nitrogen in coarse [1] bone and tankage,	15.00	15.00
Organic nitrogen in cottonseed meal, castor pomace, linseed meal, etc.,	21.00	20.00
Phosphoric acid: —		
Soluble in water,	4.50	4.50
Soluble in neutral ammonium citrate solution (reverted phosphoric acid),[2]	4.00	4.00
In fine-ground [1] bone and tankage,	4.00	4.00
In coarse [1] bone, tankage and ashes,	3.50	3.50
In cottonseed meal, castor pomace and linseed meal,	4.00	4.00
Insoluble (in neutral ammonium citrate solution) in mixed fertilizers,	2.00	2.00
Potash: —		
As sulfate free from chlorides,	5.00	5.25
As muriate (chloride),	4.25	4.25
As carbonate,	8.00	8.00
In cottonseed meal, castor pomace, linseed meal, etc.,	5.00	5.00

[1] Fine bone and tankage are separated from coarse bone and tankage by means of a sieve having circular openings one-fiftieth of an inch in diameter. Valuations of bone and tankage are based upon degree of fineness as well as upon composition.

[2] Dissolved by a neutral solution of ammonium citrate, specific gravity, 1.09, in accordance with method adopted by the Association of Official Agricultural Chemists.

(e) *Raw Products and Chemicals.*

Forty-five samples of ground bone, representing 32 analyses, have been collected and examined. The average retail cash price has been $32.63, and the average commercial valuation as calculated by the table of trade values has been $29.24. Ground bone has averaged 3.12 per cent. nitrogen, 75.32 per cent. of which has been found active by the alkaline permanganate method.

Twenty-eight samples of tankage have been inspected. The average retail cash price for tankage has been $33.19, and the average commercial valuation as calculated by the table of trade values has been $33.05 per ton. Tankage has averaged 6.58 per cent. total nitrogen, of which 75.38 per cent. has been found active by the alkaline permanganate method. Nitrogen in fine tankage has cost on the average 19.08 cents; nitrogen in coarse tankage has cost 15.06 cents per pound.

Four analyses of dissolved bone have been made. The average retail cash price has been $30.25, and the average commercial valuation as calculated by the table of trade values has been $23.27 per ton. Dissolved bone has averaged 2.60 per cent. nitrogen, 71.16 per cent. of which has been found active by the alkaline permanganate method.

Thirteen analyses of dry ground fish have been made, representing 32 samples. The average retail cash price per ton has been $42.16 and the average calculated commercial valuation $41.59 per ton. Nitrogen from dry ground fish has cost on the average 22.3 cents per pound.

(1) *Materials furnishing Nitrogen.* — Eight samples of dried blood have been examined, representing 6 analyses. Blood has averaged 10.46 per cent. total nitrogen, about 74 per cent. of which has been found active by the alkaline permanganate method. The average retail cash price for blood has been $50.74 per ton, and the average calculated commercial valuation, $48.26 per ton. The average pound cost of nitrogen from blood has been 23.13 cents.

Two samples of castor pomace have been analyzed, both of which have been found up to the guarantee. The average retail cash price has been $25.50, and the average commercial valuation calculated by the table of trade values has been $19.24 per ton. The average cost of nitrogen in this form has been 26.51 cents per pound. Castor pomace has shown on the average 4.81 per cent. nitrogen, about 54 per cent. of which has been found active by the alkaline permanganate method.

Fifty-six samples of cottonseed meal have been examined. Each sample represents a carload, and all of the material inspected was bought as a nitrogen source, largely for tobacco. The average retail cash price has been $31.45, and the average calculated commercial valuation, $25.95 per ton. The average pound cost of nitrogen in this form has been 24.24 cents. Cottonseed meal has averaged 6.49 per cent. nitrogen, about 56 per cent. of which has been found active by the alkaline permanganate method.

Thirty-nine samples of nitrate of soda have been examined, representing 16 analyses: all but one sample was found fully up to the guarantee. Nitrate of soda has cost on the average

$50.70, and the average commercial valuation calculated by the table of trade values has been $51.03 per ton. The pound price of nitrogen from this source has been 16.39 cents.

Six analyses of sulfate of ammonia have been made, representing 7 samples; all have been found of good quality. The average retail cash price per ton has been $71.13, and the calculated commercial valuation, $72.28 per ton. The average cost of a pound of nitrogen in this material has been 16.23 cents.

(2) *Materials furnishing Potash.* — Eighteen analyses of high-grade sulfate of potash have been made, representing 31 samples. The average retail cash price of this potash salt has been $50.78, and the average commercial valuation calculated from the table of trade values has been $51.47 per ton. The pound of actual potash in this form has cost on the average 5.18 cents.

Five analyses of potash-magnesia sulfate have been made, representing 9 samples. The average retail cash price has been $29.50, and the average commercial valuation calculated from the table of trade values has been $28.80 per ton. The pound of actual potash in this form has cost 5.38 cents.

An article offered as double sulfate of magnesia and potash was not *bona fide,* but evidently high-grade sulfate of potash and sulfate of magnesia reduced with sand. It contained 21.6 per cent. material insoluble in hot water, the greater part of which was unquestionably sand. The case is probably similar to several which were detected last year, and which proved to be cases where the mines in Germany had reduced high-grade sulfate of potash with sand in order to fill orders for potash-magnesia sulfate. of which there was a temporary shortage. Dr. Huston, of the German Kali Works, states that the practice is not tolerated by his company, and heavy shipments have been returned at the expense of the mines furnishing the material, and in all cases where this practice has been detected heavy fines have also been imposed. The amount of material involved in this particular case was not large, only 1½ tons being bought by one party for his own use.

Fifteen analyses of muriate of potash have been made, representing 31 samples. The potash guarantee was maintained in all but one case, and in this exception the commercial shortage was less than 50 cents per ton. The average retail cash price has been $42.58, and the calculated commercial valuation, $43.83 per ton. The pound of actual potash as muriate has cost on the average 4.13 cents.

(3) *Materials furnishing Phosphoric Acid.* — Only two samples of dissolved bone black have been analyzed, one of which showed a commercial shortage of over 50 cents per ton.

Fourteen analyses of acid phosphate have been made, representing 25 samples. The average retail cash price has been $15.35, and the average commercial valuation calculated from the table of trade values has been $13.67 per ton. The pound of available phosphoric acid from acid phosphate has cost 4.77 cents.

Seventeen analyses of basic slag phosphate have been made, representing 23 samples. Four analyses showed samples deficient in available phosphoric acid. The average retail cash price paid for basic slag was $15.19, and the average calculated commercial valuation, $12.64 per ton. The pound of available phosphoric acid from basic slag, as determined by the Wagner method, has cost on the average 4.81 cents. Two brands showed a commercial shortage of over 50 cents per ton.

(*f*) *Mixed Complete Fertilizers.*

The larger number of high-grade fertilizers that are being sold from year to year in Massachusetts indicates that the average farmer realizes the importance of purchasing a high-grade mixture. As has been pointed out in past years, there are many advantages to be gained by choosing a formula from among the high-grade goods. Summary tables have been prepared which furnish valuable data bearing upon this point.

(1) *Grades of Fertilizer.* — In separating the formulas into different grades, those brands containing plant food having a commercial value of $24 or over per ton have been classed as high grade, those having a value between $18 and $24 per ton medium grade, and those having a value of $18 or less per ton low grade.

Table showing Average Cash Price and Commercial Plant Food Value per Ton, also Money Difference between Cash Price and Plant Food Value.

	High Grade.		Medium Grade.		Low Grade.	
	1911.	1912.	1911.	1912.	1911.	1912.
Average retail cash price a ton,	$40.87	$38.23	$35.08	$33.26	$29.64	$29.76
Average retail cost of plant food in a ton.	28.89	27.84	21.04	20.74	15.37	14.58
Average money difference, .	11.98	11.16	14.01	12.52	14.27	15.16

The above table shows: —

1. That the average ton price of the three grades of fertilizer has been $1.42 less, and the average cost of plant food in a ton 66 cents less, than for the previous season.

2. That the low-grade goods were the only class which sold on the average at a slightly higher ton cost than during the previous year.

3. That the percentage excess of the selling price over the commercial value of plant food in the low-grade fertilizers is over two and one-half times more than in the high-grade goods, and about one and three-fourths times more than in the medium-grade fertilizers.

4. That with a 28.5 per cent. advance in price over the low-grade fertilizer, the high-grade furnishes about 91 per cent. increase in commercial plant food value.

5. That the money difference between the average selling price and the average valuation in the high-grade fertilizers is $4 less than in the low-grade goods. It probably costs no more to manufacture a ton of low-grade goods than it does a ton of the high-grade; besides, in the low-grade fertilizer opportunities are offered for the use of low-grade ammoniates and low-grade potash compounds. These facts all emphasize the many advantages to be gained by buying only high-grade mixtures.

Table showing the Average Composition of the Three Grades of Fertilizer.

GRADE.	Number of Brands.	Per Cent. of Whole Number.	NITROGEN.			PHOSPHORIC ACID.			Potassium Oxide.	Pounds of Available Plant Food in 100 Pounds of Fertilizer.
			Total.	Percentage Availability of Total Nitrogen.	Percentage Availability of Organic Nitrogen.	Soluble.	Reverted.	Available.		
High, . . .	165	48.25	3.94	85.28	68.65	3.90	3.52	7.42	7.75	19.11
Medium, . .	105	30.88	2.59	83.40	64.46	4.46	3.25	7.71	5.08	15.38
Low, . . .	72	21.18	1.66	75.90	60.00	4.36	2.74	7.10	2.83	11.59

The above table shows: —

1. That a ton of the average high-grade fertilizer furnishes 45.6 pounds more nitrogen and 98.4 pounds more actual potash than does a ton of the low-grade goods.

2. That a ton of the average high-grade fertilizer furnishes 27 pounds more nitrogen and 53.4 pounds more potash than does a ton of the medium-grade goods.

3. That with a 28.5 per cent. advance in price over the low-grade fertilizer, the high-grade furnishes about 65 per cent. increase in available plant food.

4. That the average high-grade fertilizer with about 15 per cent. advance in price over the medium-grade goods, furnishes over 24 per cent. more plant food and 34 per cent. increase in commercial value.

5. That the percentage activity of the total nitrogen is 9.38 per cent., and the percentage activity of the organic nitrogen is 8.65 per cent. more in the high-grade fertilizer than in the low-grade brands. This would indicate the superior quality of plant food in the high-grade brands, which is still another advantage in purchasing the latter class of fertilizer.

Table showing the Comparative Pound Cost of Nitrogen, Potash and Phosphoric Acid in its Various Forms in the Three Grades of Fertilizer.

FORM OF ELEMENT.	Low-grade Fertilizer (Cents).	Medium-grade Fertilizer (Cents).	High-grade Fertilizer (Cents).
Nitrogen (as nitrates and ammoniates), .	33.7	26.5	22.6
Nitrogen (organic), ...	38.8	30.5	26.1
Potash (as muriate), ...	8.7	6.8	5.8
Soluble phosphoric acid, ...	9.2	7.2	6.2
Reverted phosphoric acid, ...	8.2	6.5	5.5
Insoluble phosphoric acid, ...	4.1	3.2	2.7

This table shows: —

1. That the purchase of high-grade fertilizers in place of low-grade has saved nearly 12 cents on every pound of nitrogen and nearly 3 cents on every pound of potash and phosphoric acid.

2. That the purchase of high-grade fertilizers in place of medium grade has saved 4¾ cents on every pound of nitrogen and nearly 2 cents on every pound of potash and phosphoric acid.

3. That the cost of the several elements of plant food in the average high-grade fertilizer amounts to $37.65 a ton. If the farmer purchases this same amount of plant food on the basis of the cost of the fertilizer elements in the low-grade fertilizer, he would pay $56.17. In other words, he would pay $18.52 more for the same plant food if purchased in the form of low-grade fertilizer; and he would pay $12.06 more for it if purchased in the form of medium-grade fertilizer.

4. That about 52 per cent. of the brands of fertilizer sold in the State are classed as low and medium grade. This is by far too large a proportion, as it means that those purchasing this class of goods are paying an excessive price for the actual plant food obtained, which in the aggregate must amount to many thousands of dollars.

5. That it would be much more economical to buy only high-grade fertilizers and use less per acre. The brand should be selected which comes nearest fulfilling the plant-food requirements in each individual case.

(2) *Summary of Results of Analyses of the Complete Fertilizers as compared with the Manufacturer's Guarantee.*

MANUFACTURER.	Number of Brands analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
W. H. Abbott,	3	2	3	1	–	–
Alphano Humus Company,	1	1	1	–	–	–
American Agricultural Chemical Company,	76	33	66	34	8	1
Armour Fertilizer Works,	10	6	10	4	–	–
Beach Soap Company,	6	4	6	2	–	–
Berkshire Fertilizer Company,	15	12	15	3	–	–
Bowker Fertilizer Company,	26	19	23	6	1	–
Jos. Breck & Sons,	3	1	3	2	–	–
Buffalo Fertilizer Company,	8	6	7	2	–	–
The E. D. Chittenden Company,	6	4	5	1	1	–
Clay & Son,	1	1	1	–	–	–
Coe-Mortimer Company,	17	10	16	6	1	–
Eastern Chemical Company,	1	–	1	1	–	–
Essex Fertilizer Company,	9	2	6	5	2	–
C. W. Hastings,	1	1	1	–	–	–
Hubbard Fertilizer Company,	5	1	5	1	3	–
Listers' Agricultural Chemical Works,	9	6	9	3	–	–
J. E. McGovern,	1	1	1	–	–	–
Mapes' Formula and Peruvian Guano Company,	18	14	18	4	–	–
National Fertilizer Company,	15	6	11	9	1	–
Natural Guano Company,	1	1	1	–	–	–
New England Fertilizer Company,	7	6	7	1	–	–
Olds & Whipple,	7	6	7	1	–	–
Parmenter & Polsey Fertilizer Company,	8	6	8	1	1	–
R. T. Prentiss,	3	2	2	1	–	–
Pulverized Manure Company,	2	1	1	–	–	1
Rogers Manufacturing Company,	10	7	10	3	–	–
Rogers & Hubbard Company,	9	8	9	1	–	–
Ross Bros. Company,	4	2	3	2	–	–
Sanderson Fertilizer and Chemical Company,	8	5	8	3	–	–
M. L. Shoemaker & Co., Ltd.,	2	2	2	–	–	–
Swift's Lowell Fertilizer Company,	16	12	16	4	–	–
20th Century Specialty Company,	3	2	3	1	–	–
Wm. Thomson & Sons,	2	1	2	1	–	–
Whitman & Pratt Rendering Company,	5	5	5	–	–	–
Wilcox Fertilizer Company,	9	9	9	–	–	–
A. H. Wood & Co.,	3	2	3	1	–	–

This table shows: —

1. That out of a total of 330 brands of complete fertilizers collected and analyzed, 124 (38 per cent. of the total number) fell below the manufacturer's guarantee in one or more elements.

2. That 104 brands were deficient in one element.

3. That 18 brands were deficient in two elements.

4. That 2 brands were deficient in all three elements.

5. That 26 brands (about 8 per cent. of the whole number analyzed) showed a commercial shortage; that is, the value of the plant food found did not equal the value of the plant food

guaranteed, although overruns were used to offset shortages. The deficiencies found were divided as follows: —

73 brands were found deficient in nitrogen.
31 brands were found deficient in available phosphoric acid.
42 brands were found deficient in potash.

6. That, compared with the previous year, a much better showing has been made. Fewer deficiencies have occurred, also a less number of commercial shortages. The number of nitrogen, available phosphoric acid and potash shortages were, respectively, 23 less, 59 less and 24 less than for the season of 1911. The brands showing a commercial shortage were 2 less than for the previous year.

Table showing Commercial Shortages (25 Cents and Over) in Mixed Commercial Fertilizers for 1911 and 1912.

COMMERCIAL SHORTAGES.	NUMBER OF BRANDS.	
	1911.	1912.
Between $1 and $2 per ton, ...	9	8
Under $1, not less than 25 cents per ton, ...	17	15

A number of instances have occurred, as is frequently the case, where serious shortages of some one element have been found and yet the brands have not suffered a commercial shortage, the deficiencies being made up by overruns of some other element. Although this is not a desirable feature, perhaps it cannot always be avoided in the rush season.

(3) *Quality of Plant Food.* — A very full discussion of the quality of the plant food entering into the composition of mixed fertilizers will be found in our Fertilizer Bulletin No. 143. In general it may be said that the quality of the organic nitrogen used in fertilizers found in the Massachusetts markets showed an improvement over last year. The phosphoric acid guarantees, as a whole, were well maintained. There are indications that considerable nonacidulated phosphoric-acid-containing material enters into the composition of mixed fertilizers, being probably derived from tankage and partly acidulated bone. The potash guarantees were better maintained than during the

past year, and in most instances the form of potash was as guaranteed. The misleading practice of stating the sulfate of potash equivalent when the potash is actually present in form of muriate is still prevalent to some extent. Every formula has, therefore, been tested to show the form of potash actually present.

(*g*) *Ground Rock, Mineral Fertilizer or Stonemeal.*

The indications are that not much of this class of materials has been sold in the Massachusetts markets. The inspectors were not able to find it in the hands of agents, and it was probably sold by the manufacturer through soliciting agents direct to the farmer.

A sample of New Mineral Fertilizer, manufactured by the New Mineral Fertilizer Company of Boston, was taken by one of our inspectors from stock carried by the manufacturer. The analysis of this showed the presence of .09 per cent. nitrogen, .38 per cent. total phosphoric acid and .10 per cent water-soluble potash. The calculated commercial value of the material was 57 cents per ton. Extravagant claims are made by the company for the fertilizing value of the silica, chlorine, sulfur, soda, lime, magnesia, iron and alumina which the material, like all rocks and soils, contains. The ordinary soil usually contains an abundance of these elements with the possible exception of lime. Assuming the ton price to be the same as last year, $17, a pound of nitrogen would have cost $5.67, a pound of insoluble phosphoric acid 60 cents, and a pound of water-soluble potash $1.27.

Dr. Charles D. Woods, director of the Maine Agricultural Experiment Station, has conducted field experiments with this material.[1] The results of the experiment were stated as follows by Director Woods: —

> "It will be noted that both with the corn and with the potatoes, there was a somewhat smaller yield on the plots to which New Mineral Fertilizer was applied than upon the plots which received no fertilizer. The comparative yields seem clearly to point out that there was no benefit from the use of the New Mineral Fertilizer."

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[1] See description of the experiment in the American Fertilizer, Philadelphia, Pa., Vol. XXXVII., No. 9, pp. 28-29.

The Massachusetts station intends to conduct some experiments with this fertilizer the coming season.

Two samples of Stonemeal, manufactured by the Stonemeal Fertilizer Company of Paterson, N. J., who have an office in Springfield, Mass., were collected and analyzed. Although this material contains a little more potash and phosphoric acid than did the New Mineral Fertilizer, yet it must be placed in the same class.

(*h*) *Lime Compounds.*

Our new fertilizer law was drafted to include the inspection of lime used for agricultural purposes. The year 1912 marks the first official inspection of lime which has ever been made in the State.[1]

Forty-four samples representing 21 brands were taken from 36 different agents in 24 different towns; 25 analyses have been made.

Lime for agricultural purposes includes slaked or hydrated lime, caustic or burnt lime, carbonate of lime, such as ground limestone, marl and wood ashes; also gypsum or land plaster (sulfate of lime). Detailed results of the analyses will be found in our Fertilizer Bulletin, including the actual cost of 100 pounds of calcium and magnesium oxides derived from different sources.

(*i*) *Free Analysis of By-products, Fertilizers and Soils.*

Two hundred and sixty-three different substances have been received and analyzed from farmers, farmer organizations and the various departments of the experiment station. The materials may be classed as follows: fertilizers and by-products used as fertilizers, 200; soils, 40; lime compounds, 13; ash analysis of plants, 8; miscellaneous products, 2.

Many of these materials have been sampled by our regular inspectors; some were taken by the party requesting the analysis by means of a sampling tube forwarded from the station for that purpose. In all cases the samples were drawn according to directions furnished from this office. It may be assumed, therefore, that the samples were representative of the products in question. In reporting results of analysis, full information is given as to commercial value of the product and the best manner of using it. In many cases where a by-product does not have the plant food constituents present in the right proportion, suggestions are made as to the best manner of balancing the material by the addition of chemicals. In reporting analyses of lime products it has been the custom to furnish not only the chemical analysis but also the probable proportion of the various forms of lime and magnesia present; *i.e.,* whether caustic, hydrated (slaked) or carbonate of lime and magnesia were present, and amounts of each.

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[1] For a discussion of the rational use of lime, ask for Bulletin No. 137.

In reporting soil analysis, information has been furnished as to treatment with lime, manures and fertilizers.

With the exception of some of the lime products, chemicals and complete fertilizer formulas which have been collected by our inspectors, and which appear in a table by themselves in the Fertilizer Bulletin, the analyses above mentioned will not be published.

3. Report of the Feed and Dairy Section.

Mr. P. H. Smith submits the following: —

The Feed Law (*Acts and Resolves for 1903, Chapter 122*).

During the year, 902 samples of commercial feeding stuffs have been collected by James T. Howard, official inspector. These samples have been examined, and the analytical results together with additional information are given in Bulletin No. 142.

The year has been uneventful in that the law has been well complied with, and few new feeding stuffs have been found. Prices have ruled high, and our inspector reports that the stock on hand has been, during parts of the year, very low. This was due to the difficulty of getting shipments promptly and to the fact that, owing to the uncertainty of the market, dealers did not care to stock heavily.

The most important event of the year was the enactment of a new feeding stuffs law which took effect Sept. 1, 1912. This law is printed in full in Bulletin No. 142 of this station and also as Circular No. 34.

The new law differs from the law which it replaces in the following essentials: —

1. *Guarantee.* — In addition to a guarantee of the minimum percentage of protein and fat, as formerly required, a guarantee of the maximum fiber content must also be given. In case of mixed or compounded feeds, a statement of the ingredients contained therein must be included in the guarantee.

2. *Registration.* — Registration of all feeding stuffs is now necessary, although no fee is required. Upon application, the proper forms for registration will be forwarded.

3. *Appropriation.* — In place of the $3,000 formerly allowed for carrying out the provisions of the act, $6,000 is now appropriated.

4. *Phraseology.* — The law has been put in such form as to be more explicit in the statement of its requirements. Before being submitted for enactment, the text was carefully reviewed not only by officials of this station, but by those of other experiment stations, and also by a committee of feed dealers from the Boston Chamber of Commerce. It was finally submitted to a competent attorney for corrections and approval.

5. *Wheat feeds* are now included; in the former law these were omitted.

The law practically conforms to the uniform law advocated by the Association of Feed Control Officials, which has received the indorsement of the American Feed Manufacturers' Association.

It is felt that the new law will more effectually safeguard the interests of the Massachusetts farmer than the former act, and that the compliance with its requirements will not be any more difficult for the honest manufacturer or jobber. The earnest co-operation of all interested in the manufacture, sale or consumption of commercial feeding stuffs is most earnestly desired.

The acknowledgment is made of the co-operation of members of the Boston Chamber of Commerce, of the secretary of the State Board of Agriculture, of a representative of the State Grange, and of others in securing the passage of the law.

The Dairy Law (*Acts and Resolves for 1912, Chapter 218*).

This act as originally passed in 1901 required that all persons using the Babcock test as a basis of payment for milk or cream, either in buying or selling, must secure a certificate of proficiency from the experiment station. It also required that Babcock machines be inspected by an experiment station official annually, and that all glassware be tested for accuracy by the station. The act was amended in 1909 (chapter 425, Acts and Resolves for 1909), giving to the director of the experiment station the authority to revoke the certificate of an operator found to be using dirty or untested glassware or doing the work in an improper manner.

A redraft of the entire law made to include milk inspectors was presented to and passed by the Legislature of 1912, the full text of which follows: —

AN ACT TO REGULATE THE USE OF UTENSILS FOR TESTING THE COMPOSITION OR VALUE OF MILK AND CREAM.[1]

Be it enacted, etc., as follows:

SECTION 1. No bottle, pipette, or other measuring glass or utensil shall be used in this commonwealth by any inspector of milk or cream, or by any person in any milk inspection laboratory, in determining, by the Babcock or other centrifugal machine, the composition of milk or cream for the purposes of inspection; or by any person in any milk depot, creamery, cheese factory, condensed milk factory or other place in determining, by the Babcock or other centrifugal machine, the composition or value of milk or cream as a basis for payment in buying or selling, until it has been tested for accuracy and verified by the director of the Massachusetts agricultural experiment station, or by his duly designated deputy or deputies. Every such bottle, pipette, or other measuring glass or utensil shall be submitted to the said director by the owner or user thereof, to be tested for accuracy before the same is used in this commonwealth for the purposes aforesaid. The owner or user shall pay to the said director for the use of the said station as a fee for making the test, a sum not exceeding five cents for each bottle, pipette, or other measuring glass or utensil tested. Any bottle, pipette, or other measuring glass or utensil that has been tested and verified as aforesaid shall be marked by the director or by his said deputy or deputies to indicate the fact, or if tested and found to be inaccurate may be marked by him or them to indicate that it is inaccurate. No bottle, pipette, or other measuring glass or utensil that has been marked by the said director, or by his duly designated deputy or deputies, to indicate that it is inaccurate shall be used in this commonwealth by any person in determining the composition or value of milk or cream.

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[1] Chapter 218, Acts and Resolves of 1912.

SECTION 2. Every Babcock or other centrifugal machine used in this commonwealth by any inspector of milk or cream, or by any person in any milk inspection laboratory for determining the composition of milk or cream for purposes of inspection, or by any person in any milk depot, creamery, cheese factory, condensed milk factory or other place for determining the composition or value of milk or cream as a basis for payment in buying or selling, shall be subject to inspection at least once in each year by the director of the Massachusetts agricultural experiment station or by an inspector or deputy of the said director. The owner or user of any such centrifugal machine shall pay to the said director for the use of said station as a fee for making such annual inspection the actual cost of such inspection for each machine inspected.

Any Babcock or other centrifugal machine used as aforesaid that is not, in the opinion of the director, or of an inspector or deputy of the said director, in condition to give accurate results, may be condemned by the director or by his inspector or deputy. No Babcock or other centrifugal machine that has been condemned by said director or by an inspector or deputy of the director as not in condition to give accurate results shall be used in this commonwealth by any person for determining the composition or value of milk or cream as aforesaid, unless the machine be changed to the satisfaction of the said director or of his inspector or deputy, and approved by him.

SECTION 3. No inspector of milk or cream, and no person in any milk inspection laboratory, shall manipulate the Babcock or other centrifugal machine for the purpose of determining the composition of milk or cream for purposes of inspection, and no person in any milk depot, creamery, cheese factory, condensed milk factory, or other place in this commonwealth shall manipulate the Babcock or other centrifugal machine for the purpose of determining the composition or value of milk or cream as a basis for payment in buying or selling, without first obtaining a certificate from the director of the Massachusetts agricultural experiment station, or his duly designated deputy, that he is competent to perform such work. The fee for such certificate shall be two dollars, and shall be paid by the applicant therefor to the said director for the use of the said station. In case any holder of a certificate is notified by the director, or by his duly designated deputy, to correct his use of a Babcock or other centrifugal machine, the actual cost of making an inspection to ascertain if the said person has corrected his use of the said machine shall be paid by the said person or by his employer to the director for the use of the said station. No holder of a certificate whose authority to manipulate a Babcock or other centrifugal machine has been revoked by the director of the Massachusetts agricultural experiment station, or by his duly designated deputy, shall thereafter manipulate in this commonwealth any centrifugal machine for the purposes aforesaid.

SECTION 4. The director of the Massachusetts agricultural experiment station and his duly designated deputy are hereby authorized to issue certificates of competency to such persons desiring to manipulate the Babcock or other centrifugal machine as, in the opinion of the director or his deputy, are competent to manipulate said machines. The said director or his deputy may make and enforce rules governing applications for such certificates and the granting thereof and may, in his discretion, revoke the authority of any holder of a certificate who, in the opinion of the director or of his deputy, or of an inspector of the said director, is not correctly manipulating any centrifugal machine as aforesaid, or is using dirty or otherwise unsatisfactory glassware or utensils.

SECTION 5. It shall be the duty of the director of the Massachusetts agricultural experiment station, and he is hereby authorized, to test or cause to be tested all bottles, pipettes and other measuring glasses or utensils submitted to him as provided in section one, to inspect or cause to be inspected at least once each year every Babcock or other centrifugal machine used in this commonwealth by an inspector of milk or cream, or by any person in any milk inspection laboratory, for purposes of inspection, or by any person in any milk depot, creamery, cheese factory, condensed milk factory, or other place for determining the composition or value of milk or cream as a basis for payment in buying or selling, and to collect or cause to be collected for the use of said station the fees or actual cost of tests and inspections provided for in this act. The said director, his inspectors and deputies are further authorized to enter upon any premises in this commonwealth where any centrifugal machine is used as aforesaid to inspect the same and to ascertain if the provisions of this act are complied with.

SECTION 6. Any person hindering or obstructing the director of the Massachusetts agricultural experiment station, or any inspector or deputy of the said director, in the discharge of the authority or duty imposed upon him or them by any provision of this act, and any person violating any of the provisions of sections one, two and three of this act shall be punished by a fine of not less than fifteen and not more than fifty dollars for each offense.

SECTION 7. It shall be the duty of the director of the Massachusetts agricultural experiment station to see that the provisions of this act are complied with, and he may in his discretion prosecute or cause to be prosecuted any person violating any provision of this act. But this act shall not be construed to affect any persons using any centrifugal or other machine or test in determining the composition or value of milk or cream when such determination is made for the information of such persons only, and not for purposes of inspection, or as a basis for payment in buying or selling.

SECTION 8. A sum not exceeding five hundred dollars yearly shall be allowed and paid out of the treasury of the commonwealth to meet the cost of prosecutions under this act, to be paid upon the presentation to the treasurer of the commonwealth by the director of the Massachusetts agricultural experiment station of proper vouchers therefor.

SECTION 9. The word "person" as used in this act shall include a corporation, association or partnership or two or more persons having a joint or common interest.

SECTION 10. Sections sixty-five to sixty-nine, inclusive, of chapter fifty-six of the Revised Laws, and chapter four hundred and twenty-five of the acts of the year nineteen hundred and nine are hereby repealed.

SECTION 11. This act shall take effect on the first day of July in the year nineteen hundred and twelve. [*Approved March 9, 1912.*

Summary of Inspection.

1. *Examination for Certificates.* — Applicants are examined in both theory and practice of the Babcock test. Of those who have applied during the year, 28 candidates were given certificates, while 5 have been refused.

2. *Examination of Glassware.* — Six thousand and fifty-six pieces of Babcock glassware have been tested, of which only 27 pieces were condemned as inaccurate. The amount of untested glassware at present is very small as compared with that found formerly, and confirms the usefulness of the law.

Following is a summary for the twelve years the law has been in force: —

YEAR.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
1912,	6,056	27	.45
Totals,	40,208	1,924	4.79[1]

[1] Average.

3. *Inspection of Machinery and Apparatus.* — Mr. James T. Howard as deputy inspector has visited and inspected the Bab-

cock machines and apparatus in 80 creameries, milk depots and milk inspectors' laboratories. Nine operators were found using untested glassware, and 15 operators were ordered to repair or replace machines in use. As the law in its application to milk inspectors is new, no prosecutions are being considered at this time; it is believed that all will eventually conform to the law. Following is a list of milk depots, creameries and milk inspectors visited. Only those milk inspectors using the Babcock test are listed.

1. *Creameries.*

LOCATION.	Name.	Manager or Proprietor.
1. Amherst,	Amherst,	R. W. Pease, manager.
2. Amherst,	Fort River,[1]	E. A. King Estate, Proprietors.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
6. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
7. Egremont,	Egremont Co-operative,	E. A. Tyrell, manager.
8. Easthampton,	Easthampton Co-operative,	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company,	Walter Solomon, proprietor.
11. Monterey,	Berkshire Hills,	F. A. Campbell, manager.
12. Northfield,	Northfield Co-operative,	John E. Nye, manager.
13. Shelburne,	Shelburne Co-operative,	I. R. Barnard, manager.
14. Wyben Springs,	Wyben Springs Co-operative,	C. H. Kelso, manager.

[1] Testing done at Massachusetts Agricultural Experiment Station.

2. *Milk Depots.*

LOCATION.	Name.	Manager.
1. Boston,	Boston Condensed Milk Company,	R. Burns.
2. Boston,	Boston Jersey Creamery,	E. F. Luce.
3. Boston,	Elm Farm Milk Company,	J. H. Knapp.
4. Boston,	Franklin Creamery,	O. Bradford.
5. Boston,	H. P. Hood & Sons,	C. H. Hood.
6. Boston,	Oak Grove Farm,	John Alden.
7. Boston,	Plymouth Creamery Company,	R. Gardner.
8. Boston,	Turner Center Dairying Association,	I. L. Smith.
9. Boston,	Walker-Gordon Laboratory,	G. Franklin.

Location.	Name.	Manager.
10. Boston, ...	D. Whiting & Sons, ...	George Whiting.
11. Cambridge, ...	C. Brigham Company, . . .	J. K. Whiting.
12. Cheshire, ...	Ormsby Farms, ...	E. B. Penniman.
13. Lawrence, ...	Crescent Creamery, ...	E. Morgan.
14. Newburyport, ...	Newhall's Milk Depot, . . .	John A. Newhall.
15. Pittsfield, ...	H. H. Prentice & Co., . . .	H. H. Prentice.
16. Sheffield, ...	Willow Brook Dairy, ...	Frank Percy.
17. Southborough, . . .	Deerfoot Farm, ...	C. H. Newton.
18. Springfield, ...	Tait Brothers, ...	H. Tait.

3. *Milk Inspectors.*

Location.	Inspector.	Location.	Inspector.
1. Adams, ...	A. G. Potter.	26. Newton, ...	Arthur Hudson.
2. Andover, ...	F. H. Stacey.	27. New Bedford, . .	H. B. Hamilton.
3. Amesbury, . . .	E. L. Worthen.	28. North Adams, . .	H. Tower.
4. Arlington, ...	L. L. Pierce.	29. Northampton, . .	G. R. Turner.
5. Barnstable, ...	Geo. T. Mecarta.	30. Peabody, ...	H. S. Pomeroy.
6. Boston, ...	J. O. Jordan.	31. Pittsfield, ...	E. L. Hannum.
7. Brockton, ...	G. G. Bolling.	32. Plainville, . . .	John Eiden.
8. Cambridge, . . .	Wm. A. Noonan.	33. Revere, ...	J. E. Lamb.
9. Chelsea, ...	W. S. Walkley.	34. South Hadley, . .	Geo. F. Boudreau.
10. Chicopee, ...	C. L. O'Brien.	35. Somerville, . . .	H. E. Bowman.
11. Clinton, ...	G. L. Chase.	36. Springfield, . . .	S. C. Downs.
12. Everett, ...	E. Clarence Colby.	37. Springfield, . . .	Emerson Laboratory.[1]
13. Fall River, ...	Henry Boisseau.	38. Taunton, . . .	L. I. Tucker.
14. Fitchburg, ...	John F. Bresnahan.	39. Wakefield, . . .	J. S. Bonney.
15. Gardner, ...	C. W. Shippee.	40. Waltham, ...	Arthur L. Stone.
16. Greenfield, . . .	Geo. P. Moore.	41. Ware, ...	Fred E. Marsh.
17. Haverhill, ...	H. L. Conner.	42. Watertown, . . .	L. C. Simmons.
18. Holyoke, ...	D. P. Hartnett.	43. Wellesley, ...	F. Schneider, Jr.
19. Lawrence, ...	J. H. Tobin.	44. Westfield, ...	W. M. Porter.
20. Lowell, ...	Melvin Marster.	45. West Springfield, .	Norman T. Smith.
21. Ludlow, ...	A. L. Bennett,	46. Winchendon, . .	G. W. Stanbridge.
21. Lynn, ...	H. P. Bennett.	47. Winchester, . . .	Morris Dinneen.
23. Millbury, ...	F. A. Watkins,	48. Woburn, ...	E. P. Kelley.
24. Malden, ...	J. I. Sanford.	49. Worcester, . . .	Gustav L. Berg.
25. Medford, ...	Winslow Joyce.		

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[1] Does work for the State Dairy Bureau.

Water Analysis.

There is no one feature of the home of greater importance than a pure and unfailing water supply. In order that families living where a public supply is not available may have the opportunity of determining the purity of the water from the well or spring they are obliged to use, the experiment station will make a chemical examination of the water at a nominal charge ($3 a sample). Water for examination must be shipped in containers, which will be sent to the applicant on request, and the blank forms sent with the container must be filled out and returned with the sample. A bacteriological examination is not made, and the chemical analysis is limited to those determinations which will indicate sewage contamination or the presence of lead or objectionable metals.

One hundred and ten samples were examined during the past year; of these there were 77 samples from wells, 28 from springs, 4 from ponds and 1 sample of ice. A large number of well waters examined were condemned. Some showed only slight contamination while others were pronounced dangerous for use.

Wells located close to dwellings and stables are particularly liable to contamination; hence great care should be exercised in the location of new wells. Where a well is known to be free from contamination it should be bricked or cemented up well above the surface of the ground in order to prevent the entrance of surface water during wet weather, and the top of the well should be made vermin proof.

Milk, Cream and Feeds for Free Examination.

In addition to the other work of this department, free analyses have been made of 372 samples of milk and 146 samples of feedstuffs. A large number of butter-fat tests on cream by the Babcock method have also been made.

As a general rule, it is preferred to have application made before a sample is submitted for analysis. Directions for proper sampling and for shipping can then be forwarded. An analysis of an improperly drawn sample may lead to erroneous conclusions. In the case of feeding stuffs an analysis is often unnecessary, as the experiment station has a large amount of analytical data on file which may apply to the sample submitted. This department will not act in the capacity of a commercial chemist, and will use its own discretion in accepting work of this character.

Miscellaneous Work.

In addition to the work already described, this section has conducted investigations, co-operated with other departments, or made analyses as follows: —

1. It has arranged and furnished exhibits and speakers in co-operation with the extension department for fairs, farmers' meetings and expositions.
2. It has co-operated with the Bowker Fertilizer Company in making starch determinations on potatoes in connection with the awarding of prizes.
3. It has co-operated with the agricultural department of the college in making analyses of milk in connection with the awarding of prizes at a dairy show held during "farmers' week."
4. In connection with the experimental work of this and other departments of the experiment station, this section has made analyses of 160 samples of milk, 129 samples of feed and 478 samples of agricultural plants.

Testing Pure-bred Cows.

The work of testing pure-bred cows for entry in the advanced register of the several pure-bred cattle associations continues to increase. During the year, thirteen different men have been used for the Holstein-Friesian work, and for a greater part of the time three men have been employed in the yearly tests for the Guernsey, Jersey and Ayrshire associations. From Dec. 1, 1910, to Dec. 1, 1911, 69 Guernsey, 94 Jersey and 4 Ayrshire tests have been completed. There are now on test 82 Guernseys, 106 Jerseys and 16 Ayrshires, located at 22 different farms. For the Holstein-Friesian Association there have been completed 124 seven-day tests, 7 thirty-day tests, 2 fourteen-day tests and 1 fifty-seven-day test.

The Jersey, Guernsey and Ayrshire clubs are formulating uniform rules for testing, and will probably, in the near future, adopt a one-day monthly test instead of the two-day test now in use.

4. Numerical Summary of Substances examined in the Chemical Laboratory.

The following substances have been received and examined: 110 samples of water, 372 of milk, 2,618 of cream, 146 feedstuffs, 200 fertilizers and fertilizer refuse materials, 40 soils, 13 lime products, 8 ash analyses of plants and 2 miscellaneous. There have also been examined in connection with experiments in progress by the several departments of the station, 160 samples of milk and cream, 129 cattle feeds and 478 agricultural plants. In connection with the control work there have been collected 1,180 samples of fertilizer and 902 samples of feedstuffs. The total for the year was 6,359.

The above does not include the work of the research section. In addition, 28 candidates have passed the examination and secured certificates to operate the Babcock test, and 6,056 pieces of Babcock glassware have been tested for accuracy, of which only 27 pieces, or .45 of 1 per cent., were condemned as inaccurate.

5. Correspondence.

The number of letters sent during the year approximates 6,500, the data being based upon the number of stamped envelopes used. In addition a large number of circular letters have been mailed as an adjunct to our inspection work. The larger part of the correspondence is devoted to work in connection with the inspection of fertilizers, cattle feeds, dairy apparatus and the testing of pure-bred cows. A considerable amount of time, however, is still given to answering special inquiries made by farmers and others relative to plant and animal feeding, and the composition and value of fertilizers, cattle feeds and milk.

THE FOOD VALUE OF PLAIN AND MOLASSES BEET PULP.

J. B. LINDSEY.

A few years ago [1] the writer published a brief review of the value of beet residues for farm stock. Since this publication two experiments have been made at this station comparing both the plain and molasses pulp (dried) with corn meal for milk production.

Beet pulp is the residue from the manufacture of sugar from sugar beets. After the beets are shredded and the sugar removed with water by the diffusion process, the residue is run through presses to reduce the water content and then put into kilns and thoroughly dried. The dried plain pulp is coarse and of a gray color. Molasses beet pulp is the pressed plain pulp mixed with the residuum beet molasses and dried. Another method of making the molasses pulp is to mix a definite amount of molasses with the dried pulp. It is understood that but little molasses pulp is now being made.

COMPOSITION OF THE BEET PULP.

	Plain Pulp.	Molasses Pulp.	Corn Meal [2] for Comparison.	
Water,	9.08	8.48	14.99	15.60
Ash,	3.02	6.93	.86	.85
Protein,	8.90	11.16	7.88	7.82
Fiber,	18.76	10.16	.81	.80
Extract matter,	60.59	62.76	69.76	69.27
Fat,	.65	.51	5.70	5.66
Totals,	100.00	100.00	100.00	100.00

It will be noted that the plain pulp contained about 9 per cent. of water, a relatively large amount of fiber, and practically no fat. The molasses pulp contained considerably more ash, due to the large amount of mineral matter in the molasses. The fiber content was considerably less than that of the plain pulp, due to the replacing of the pulp by the molasses which was without fiber. The amount of molasses added to the pulp appears to vary more or less in different samples.

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[1] Twenty-second report of this station, Part II., pp. 21-27.

[2] Samples used in experiment.

Both the plain and the molasses pulp are carbohydrate feeds similar to corn meal, being relatively low in protein and high in carbohydrates. The extract matter of the molasses pulp contains considerable sugar, while in the plain pulp there is much less sugar and more of the hemicellulose. The carbohydrates of the corn meal consist largely of starch, while those of the plain beet pulp are made up of a high percentage of fiber together with the hemicellulose and some sugar.

Coefficients of Digestibility of Beet Pulp.

Three single trials were made with each sample of the beet pulp with the following average results: —

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Plain pulp,	75	26	52	83	83	–
Plain pulp,[1]	77	–	51	72	86	–
Molasses pulp,	82	51	61	77	90	–
Molasses pulp,[2]	85	–	64	84	91	–
Average molasses pulp,	83	51	63	80	90	–
Corn meal for comparison,	88	–	67	–	92	90

[1] German experiments.
[2] Three earlier trials.

The coefficients for plain pulp made at this station are reasonably close to those of German origin. The molasses pulp shows higher coefficients than the plain pulp. Part of this is due, however, to the high ash percentage and its increased digestibility.

Pounds of Digestible Organic Matter in a Ton.

	Protein.	Fiber.	Extract Matter.	Fat.	Totals.
Plain pulp,	92.56	311.42	1,005.79	–	1,409.77
Molasses pulp,	140.62	162.56	1,129.68	–	1,432.86
Corn meal for comparison,	105.59	–	1,283.58	101.88	1,491.05

It will be seen from the coefficients that while the dry matter in the molasses pulp has a higher digestibility than that in the plain pulp, and while the dry matter in the corn meal shows an increased digestibility over either of the pulps, the digestibility of the total organic nutrients in *one ton* of the several feeds does not vary widely. This is explained on the ground that the molasses pulp contains noticeably more ash than the plain pulp, and that the corn meal has some 6 per cent. more water than the dried pulps. On the basis of digestible organic nutrients in one ton, it would appear that the corn meal was substantially 5 per cent. more valuable than the average of the two pulps. Calculations made on the basis of net energy value show the corn meal to furnish 20 per cent. more energy than the dried pulp. This is due to the increased energy assumed to be required to digest the fiber contained in the pulp. It is doubtful, however, if the soft beet fiber causes as much energy loss as do the harder fibers of the hays and straw. One may conclude that in practical feeding trials comparatively little difference would be noted, pound for pound, between the two feeds, especially if the amounts of each feed fed did not exceed 5 pounds daily to each animal.

FEEDING EXPERIMENTS WITH COWS.

1. *Plain Pulp* v. *Corn Meal.*

Six cows were fed by the reversal method in periods lasting five weeks.

History of Cows.

Cows.	Breed.	Age (Years).	Last Calf dropped.	Yield of Milk at Beginning of Experiment (Pounds).
Amy,	Pure Jersey,	2	September 18,	14.8
Betty,	Grade Jersey,	5	September 21,	20.8
Cecile,	Pure Jersey,	4	October 23,	27.6
Fancy II.,	Grade Jersey,	2	September 30,	14.6
Daisy,	Grade Jersey,	11	October 9,	21.5
Gladys,	Pure Jersey,	6	October 10,	22.7

Duration of Experiment.

DATES.	Cows.		Length of Period (Weeks).
	Plain Beet Pulp.	Corn Meal.	
December 4 through January 7, .	Amy, Betty, Cecile,	Fancy II., Daisy, Gladys.	5
January 14 through February 18, .	Fancy II., Daisy, Gladys.	Amy, Betty, Cecile,	5

The method of caring for, feeding and weighing the animals, of sampling the feeds and milk, was the same as described under the oat *v.* corn meal experiment published elsewhere in this report. The milk was sampled for five consecutive days on the first, third and fifth week of the experiment.

Character of Feeds. — The hay was early cut and well cured, being an admixture of Kentucky blue grass with some clover and sweet vernal grass. The corn meal and spring bran were of good average quality. Cottonseed meal was of good color, but rather below the average in protein. The plain beet pulp was of normal character.

Total Feeds consumed by Each Cow (Pounds).

Corn Meal Ration.

Cows.	Hay.	Bran.	Corn Meal.	Cotton-seed Meal.	Beet Pulp.
Amy, ...	546	70	105	35	–
Betty, ...	629	70	175	18	–
Cecile, ...	663	70	175	28	–
Daisy, ...	630	72	175	18	–
Fancy II., ...	490	70	105	–	–
Gladys, ...	630	70	175	18	–
Totals, ...	3,588	422	910	117	–
Beet Pulp Ration.					
Amy, ...	477	70	–	35	105
Betty, ...	625	70	–	18	175
Cecile, ...	663	70	–	35	175
Daisy, ...	628	70	–	18	175
Fancy II., ...	546	68	–	–	99
Gladys, ...	628	70	–	18	175
Totals, ...	3,567	418	–	124	904

Average Daily Ration consumed by Each Cow (Pounds).

CHARACTER OF RATION.	Hay.	Bran.	Corn Meal.	Cotton-seed Meal.	Beet Pulp.
Corn meal,	17.09	2.01	4.33	.67	–
Beet pulp,	16.99	1.99	–	.71	4.30

It will be seen that the different cows were fed somewhat different amounts of the several feedstuffs, depending upon their individual needs. The basal ration consisted of hay, bran and cottonseed meal to which were added an average of 4.3 pounds of corn meal or beet pulp daily. A slight error occurred in that 3.91 pounds of dry matter were fed in the form of beet pulp as against 3.70 in case of corn meal, due, of course, to the higher moisture content of the meal.

Dry Matter and Digestible Organic Nutrients in Average Daily Rations (Pounds).

CHARACTER OF RATION.	Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.[1]	
Corn meal,	21.12	1.57	2.96	8.17	.53	13.87	1:7.83
Dried beet pulp,	21.29	1.54	3.53	7.60	.32	13.37	1:7.68
Haecker Standard.[2]							
Corn meal,	–	1.59	–	10.66	.46	13.26	1:7.34
Dried pulp,	–	1.60	–	10.70	.46	13.31	1:7.32
Savage Standard.[3]							
Corn meal,	–	1.97	–	–	–	14.02	1:6.12
Dried pulp,	–	1.97	–	–	–	14.07	1 :6.14

[1] Including fat multiplied by 2.2.

[2] Bulletin No. 79, Minnesota Experiment Station.

[3] Bulletin No. 323, Cornell Experiment Station.

The data in the first subdivision indicate the amounts of digestible nutrients contained in the feeds actually fed. The corn meal ration contained .5 pound of total nutrients in excess of the dried beet pulp ration. The nutrients in the two rations fed agree quite closely with the Haecker standard. The Haecker standard as modified recently by Savage calls for both more protein and more total nutrients. It would probably have been advisable in case of our experiment to have reduced the basal ration of hay, bran and cottonseed meal a little in order to have secured a more pronounced effect — if any — of the corn meal and plain beet pulp. On the basis of digestible nutrients actually consumed, one would not expect much difference in the milk yield.

Herd Gain or Loss in Live Weight (Pounds).

Corn meal ration, ...	33—
Beet pulp ration, ...	37+

A slight difference in favor of the pulp was noted.

Yield of Milk and Milk Ingredients (Pounds).

Corn Meal.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (1/6 added).
Amy, ...	503.2	14.5	78.26	30.75	35.88
Betty, ...	714.1	20.4	103.33	38.20	44.57
Cecile, ...	901.5	25.8	127.65	46.31	54.06
Daisy, ...	639.4	18.3	98.21	37.34	43.56
Fancy II., ...	454.8	13.0	62.22	22.06	25.73
Gladys, ...	723.3	20.7	105.02	40.58	47.34
Totals, ...	3,911.3	18.8[1]	574.69	215.27	251.14

Beet Pulp.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (1/6 added).
Amy, ...	482.6	13.8	72.78	28.14	32.83
Betty, ...	699.6	20.0	102.07	36.87	43.02
Cecile, ...	856.2	24.5	121.75	43.15	50.34
Daisy, ...	718.4	20.5	109.31	41.74	48.70
Fancy II., ...	482.5	13.8	65.48	22.97	26.80
Gladys, ...	777.8	22.2	112.86	43.63	50.90
Totals, ...	4,017.1	19.1[1]	584.28	216.50	252.59

[1] Average.

The above results show no striking variations in the yields. The beet pulp ration produced substantially 2 per cent. more milk and milk solids than did the corn meal ration. This is within the limit of error. It may have been due partly to the superior mechanical effect of the pulp, although this is pure assumption.

Average Composition of the Herd Milk.

CHARACTER OF RATION.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Corn meal, ...	14.58	5.46	9.12
Beet pulp, ...	14.54	5.39	9.15

Differences in the composition of the milk are not noted.

Food Cost of Milk and Butter.

CHARACTER OF RATION.	Total Milk.	100 Pounds Milk.	1 quart Milk (Cents).	1 Pound Butter (Cents).
Corn meal, ...	$50 80	$1 29	2.90	17.9
Beet pulp, ...	47 89	1 22	2.85	16.6

The beet pulp cost some $6 a ton less than the corn meal at the time the experiment was in progress; hence the cost of the milk produced was also less (some 6 per cent.).

Dry and Digestible Matter required to produce Milk and Milk Ingredients (Pounds).

CHARACTER OF RATION.	DRY MATTER.			DIGESTIBLE NUTRIENTS.		
	100 Pounds Milk.	1 Pound Solids.	1 Pound Fat.	100 Pounds Milk.	1 Pound Solids.	1 Pound Fat.
Corn meal, ...	112.00	7.68	20.51	70.17	4.81	12.85
Beet pulp, ...	110.72	7.61	20.54	67.54	4.64	12.53

The above figures include the food material required for maintenance. They show that a little less dry and digestible organic nutrients were required to produce like amounts of milk and milk ingredients with the beet pulp than with the corn meal ration.

2. *Molasses Beet Pulp v. Corn Meal.*

This trial followed directly after the one with plain beet pulp already described. The same cows were used.

Duration of Experiment.

Dates.	Cows.		Length of Period (Weeks).
	Corn Meal.	Molasses Beet Pulp.	
February 26 through April 1,	Amy, Betty, Cecile,	Daisy, Fancy II., Gladys.	5
April 8 through May 13,	Daisy, Fancy II., Gladys.	Amy, Betty, Cecile,	5

Total Feeds consumed by Each Cow (Pounds).

Corn Meal Ration.

Cows.	Hay.	Bran.	Cotton-seed Meal.	Corn Meal.	Molasses Beet Pulp.
Amy,	487	70	35	105	-
Betty,	622	70	18	175	-
Cecile,	660	70	28	175	-
Daisy,	628	70	18	175	-
Fancy II.,	474	70	-	105	-
Gladys,	630	70	18	175	-
Totals,	3,501	420	117	910	-

Molasses Beet Pulp Ration.

Cows.	Hay.	Bran.	Cotton-seed Meal.	Corn Meal.	Molasses Beet Pulp.
Amy,	490	70	35	-	105
Betty,	628	70	18	-	175
Cecile,	665	70	35	-	175
Daisy,	627	73	18	-	175
Fancy II.,	398	70	-	-	105
Gladys,	630	70	18	-	175
Totals,	3,438	423	124	-	910

Average Daily Ration consumed by Each Cow (Pounds).

Character of Ration.	Hay.	Bran.	Cotton-seed Meal.	Corn Meal.	Molasses Beet Pulp.
Corn meal,	16.67	2.00	.67	4.33	-
Molasses beet pulp,	16.37	2.01	.71	-	4.33

The cows consumed slightly less hay during the molasses beet pulp half of the trial. It will be noted that hay, bran and cottonseed meal constituted the basal ration, and that 4.33 pounds of corn meal were compared with a like amount of beet pulp.

Dry Matter and Digestible Organic Nutrients in Average Daily Rations (Pounds)

Character of Ration.	Dry Matter.	Digestible Organic Nutrients.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.[1]	
Corn meal, . .	20.90	1.50	2.83	8.22	.53	13.72	1:8.15
Molasses beet pulp,	20.98	1.59	3.15	7.86	.32	13.30	1:7.36
Haecker Standard.[2]							
Corn meal, . .	–	1.68	–	11 17[3]	.48	13.92	1.7.29
Molasses beet pulp, .	–	1.61	–	10.68	.46	13 30	1:7.26
Savage Standard.[2]							
Corn meal, . .	–	2.08	–	–	–	14.73	1:6.08
Molasses beet pulp, .	–	1.99	–	–	–	14.07	1:6.07

[1] Including fat multiplied by 2.2.
[2] Already cited.
[3] Fiber included.

It appears that the two rations contained substantially equal amounts of total digestible nutrients and ought to produce about the same amount of milk. The molasses pulp ration contained rather more fiber, but the excess being derived from beet pulp should not have required much more energy for its digestion than the extract matter. These nutrients fed correspond quite closely to the Haecker standard as stated above. They are not quite as liberal as those recently suggested by Savage. If the basal ration of hay, bran and cottonseed meal fed had been a little less, it would have brought out a trifle more sharply the difference — if any — in feeding value between the corn meal and the molasses pulp.

Herd Gain or Loss in Live Weight (Pounds).

Corn meal ration, ...	109+
Molasses beet pulp ration, ...	90+

A slight gain occurred on both rations, indicating that the animals were advancing in lactation and not devoting as much of their food to milk as in the former experiment.

Yield of Milk and Milk Ingredients (Pounds).

Corn Meal.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (1/6 added).
Amy,	595.6	17.0	90.83	35.74	41.70
Betty,	821.5	23.6	120.46	44.28	51.66
Cecile,	984.9	28.1	113.20	53.28	62.16
Daisy,	682.1	19.5	103.98	41.06	47.90
Fancy II.,	370.3	10.6	50.81	18.11	21.13
Gladys,	726.6	20.8	104.49	40.90	47.72
Totals,	4,184.0	19.9[1]	613.77	233.37	272.27

Molasses Beet Pulp.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (1/6 added).
Amy,	481.6	13.8	72.09	28.27	32.98
Betty,	647.5	18.5	93.37	33.22	38.76
Cecile,	763.9	21.8	109.77	39.88	46.53
Daisy,	797.5	22.8	116.59	45.30	52.85
Fancy II.,	496.8	14.2	71.24	25.59	29.86
Gladys,	867.1	24.8	125.56	48.30	56.35
Totals,	4,054.4	19.3[1]	588.62	220.56	257.33

[1] Average.

The herd produced some 3 per cent. less milk and 4 per cent. less solids while on the molasses pulp ration. Such results will have to be considered substantially within the limit of error. At least, no wide difference in yield is noted.

Average Composition of the Herd Milk.

CHARACTER OF RATION.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Corn meal,	14.67	5.58	9.09
Molasses beet pulp,	14.52	5.44	9.08

The milk produced with the pulp ration appears to be slightly lower in fat than that produced by the corn meal ration. The difference is not marked and much emphasis cannot be placed upon it.

Food Cost of Milk and Butter.

CHARACTER OF RATION.	Total Milk.	100 Pounds Milk.	1 quart Milk (Cents).	1 Pound Butter (Cents).
Corn meal,	$50 08	$1 19	2.68	16.1
Molasses beet pulp,	47 46	1 17	2.63	16.1

The milk produced by the beet pulp ration cost a little less because the pulp at the time could be purchased for noticeably less money per ton than the corn meal.

Dry and Digestible Matter required to Produce Milk and Milk Ingredients (Pounds).

CHARACTER OF RATION.	DRY MATTER.			DIGESTIBLE NUTRIENTS.		
	100 Pounds Milk.	1 Pound Solids.	1 Pound Fat.	100 Pounds Milk.	1 Pound Solids.	1 Pound Fat.
Corn meal,	101.40	7.12	18.72	65.35	4.45	11.72
Molasses beet pulp,	108.10	7.45	19.87	66.56	4.58	12 23

The results are slightly in favor of the corn meal ration.

GENERAL CONCLUSIONS.

1. On the basis of dry matter the plain and molasses beet pulps contain substantially equal quantities of digestible organic nutrients; on the same basis corn meal has about 13 per cent. more digestible nutrients.

2. On a natural moisture basis (9 per cent. for the pulps and 15 per cent. for the corn meal) corn meal has about 5 per cent. more digestible organic nutrients than the dried beet pulps.

3. The results of the two feeding trials reported show that the rations containing the beet pulp produced substantially as much milk as those containing corn meal.

The Place of Dried Beet Residues in the Farm Economy.

Farmers who are in a position to produce their own feed cannot afford, as a rule, to purchase starchy feedstuffs; they should be produced upon the farm, in the form of corn, oats and barley. For milk production it is much more desirable to purchase materials rich in protein, such as cottonseed and linseed meals, dried distillers' and brewers' grains, gluten feed, malt sprouts, fine middlings and even bran. These feedstuffs are not only very helpful in milk production, but likewise supply large amounts of nitrogen in the resulting manure. When the supply of home-grown corn is exhausted or limited, beet residues may be substituted for fattening stock and as one-third of the grain ration for dairy purposes. Milk producers who purchase all of their grain will find the dried pulp a satisfactory component (one-third to one-half) of the daily ration. It can also be fed, in amounts of from 8 to 10 pounds of dried pulp daily, as a partial substitute for roughage. It should be mixed with two to three times its weight of water.

THE VALUE OF OATS FOR MILK PRODUCTION.

J. B. LINDSEY.

Oats are held in high esteem as a food for all classes of farm animals, and particularly for horses. They are also regarded as a valuable food for milk production, although their relative cost, especially in the east, has prevented their use for this purpose. For example, the average wholesale price for a ton of oats in 1910 was $29.51, and for the first eight months of 1911 it was $26.99, as against $26.39 and $23.88 for corn meal.

The fact that oats are so highly regarded for the production of milk led the station to conduct three demonstration experiments with dairy cows, comparing ground oats with a like amount of corn meal.

THE COMPOSITION OF OATS (PER CENT.).

	Oats fed.	Average American Analyses.[1]	Average Foreign Analyses.[2]	Corn Meal fed.	Corn Meal. Average Massachusetts Analyses.[3]
Water,	10.80	10.40	13.30	14.50	11.00
Ash,	3.25	3.20	3.10	.86	1.30
Protein,	12.15	11.40	10.30	7.93	9.80
Fat,	4.41	4.80	4.80	5.74	3.90
Fiber,	8.94	10.80	10.30	.81	2.00
Extract matter,	60.45	59.40	58.20	70.16	72.00
	100.00	100.00	100.00	100.00	100.00

[1] Henry, 1910.
[2] Kellner, 1909.
[3] Lindsey's Compilation, 1910.

Oats vary in composition rather more than some other cereals. The larger the percentage of hulls the lower the percentages of protein and fat. Oats that are imperfectly developed are likely to have relatively more protein and less starchy matter than those that have been well formed. The percentage of hulls varies between 20 and 35, with a probable average of 26. It was held formerly that oats contained an alkaloid avenin which accounted for their peculiar effect in imparting spirit to horses, but more recent investigations have failed to identify this product. E. Schulze identified an alkaloid Trigonellum in the oat, but the amount found was so small as to be without influence as a stimulant.

The corn meal fed in the present experiment was the usual material now offered in the general markets. It evidently was not ground corn kernels, but a sifted product resulting from the manufacture of cracked corn. The analysis of corn meal given for comparison represented the average of 119 samples of ground corn kernels. It is higher in protein and fiber and lower in fat than the sifted product.

Oats differ from corn in having noticeably more ash, rather more protein and decidedly more fiber.

THE DIGESTIBILITY OF OATS.

The coefficients of digestibility were not determined in the particular sample fed. Here follow the average coefficients obtained for American and German oats: —

	American.[1]	Foreign.[2]	Corn Meal for Comparison.
Dry matter,	70	70	88
Ash,	25	–	67
Protein,	77	76	–
Fiber,	31	26	–
Extract matter,	77	76	92
Fat,	89	80	90

[1] Lindsey. [2] Kellner.

Applying the above coefficients to the average composition of American and foreign oats, and to the average analysis for corn meal, we have the following amounts of digestible matter in 100 pounds: —

	American Oats.	Foreign Oats.	American Corn Meal.
Protein,	8.78	7.83	6.57
Fiber,	3.35	2.68	–
Fat,	4.27	3.84	3.51
Extract matter,	45.74	44.23	66.24
Total,	62.14	58.58	76.32

One hundred pounds of corn contains, therefore, some 16 pounds, or 27 per cent., more digestible material than a like amount of oats.

Kellner placed the net energy value of corn at 81.5, and of oats at 59.7, or as 100 is to 73.2 (starch equivalents). One would, therefore, assume that for the ordinary purposes of nutrition oats were substantially one-fourth less valuable than corn. This does not take into account the favorable mechanical or special energy effects of oats. The nutritive inferiority of oats is due to the large percentage of indigestible hull. The oat kernel free from hull is easily and highly digestible.

FEEDING EXPERIMENTS WITH OATS FOR MILK PRODUCTION.

The object of the experiments was to compare a definite amount of oats with a like amount of corn meal (*a*) upon the general condition and weight of each animal and (*b*) upon the yield of milk, milk solids and fat.

The plan of the experiments consisted in taking four cows, all of which were fresh in late summer, and dividing them into two groups of two each. In the first half of the trial two of the cows received the so-called oat ration at the same time the other two cows were receiving the corn meal ration. In the second half of the trial the rations were reversed. The experiment was carried out three times.

History of the Cows, 1909–10.

Cows.	Breed.	Age (Years).	Last Calf dropped.	Yield of Milk at Beginning of Period (Pounds).
Samantha,	Grade Holstein,	6	August 18,	27.2
Minnie,	Grade Holstein,	6	August 26,	25.8
Ida,	Pure Jersey,	2	August 19,	19.3
Red III.,	Grade Jersey,	4	September 3,	27.6
May Rio,	Pure Jersey,	7	November 11,	24.2

The first four cows were used in Experiments I. and II.; cow May Rio was substituted for Minnie in Experiment III.

Duration of the Three Experiments, 1909–10.

Experiment I.

Dates.	Cows.	Ration.
October 16, through November 12,	Minnie and Samantha	Corn meal.
	Red III. and Ida.	Ground oats.
November 20, through December 17,	Red III. and Ida.	Corn meal.
	Minnie and Samantha.	Ground oats.

Experiment II.

Dates.	Cows.	Ration.
December 25, through January 21,	Minnie and Samantha	Corn meal.
	Red III. and Ida.	Ground oats.
January 29, through February 25,	Red III. and Ida.	Corn meal.
	Minnie and Samantha.	Ground oats.

Experiment III.

Dates.	Cows.	Ration.
March 4, through April 1,	Samantha and Red III.	Corn meal.
	Ida and May Rio.	Ground oats.
April 9, through May 6,	Ida and May Rio.	Corn meal.
	Samantha and Red III.	Ground oats.

It will be seen that each period lasted twenty-eight days with an interval of seven days between each experiment and each half.

General Care, Feeding and Weighing. — The cows were kept in roomy stalls, carded daily, and turned into the barnyard for from four to six hours each pleasant day. The daily feed was given in two portions, and water was kept continuously before each animal. All the cows were in good condition at the beginning of the trial.

Each animal was weighed for three consecutive days at the beginning and end of each half of the trial. The weighing was done in the afternoon as the cows were brought in from the yard, previous to feeding and watering.

Sampling Feeds and Milk. — The hay was sampled at the beginning, middle and end of each half of the trial. This was accomplished by taking forkfuls here and there from the day's feeding and running them through a cutter. The cut hay was mixed, subsampled, and the final sample placed in a glass-stoppered bottle and brought to the laboratory at once for a dry-matter test. An aliquot of each of the several samples of hay was mixed and analyzed. The bran, ground oats and corn meal were sampled by taking a like amount daily and placing in glass-stoppered bottles. At the end of each half of the trial a dry-matter determination was made, and at the end of three trials an aliquot of each sample was mixed and analyzed. The milk of each cow was sampled twice daily for five consecutive days on the second and fourth week of each half of the trial, preserved in glass-stoppered bottles with the aid of formalin and tested for solids and fat. The method of sampling consisted in mixing the freshly drawn milk with an especially constructed mixer, and immediately removing a definite amount with a long-handled small dipper.

Character of Feeds. — Hay, fine and early cured, largely Kentucky blue grass with more or less clover and sweet vernal grass. Ground oats, corn meal and bran of average quality.

Total Feeds consumed (Pounds).

Experiment I.

	Corn Meal Ration.			Oat Ration.		
	Hay.	Bran.	Corn. Meal.	Hay.	Bran.	Oats.
Minnie,	560	84	112	558	84	112
Samantha,	644	112	140	642	112	140
Red III.,	559	84	140	560	84	140
Ida,	501	84	112	510	81	108
Totals,	2,265	364	504	2,274	361	500
Average per cow daily,	20.22	3.25	4.5	20.30	3.22	4.46
Experiment II.						
Minnie,	544	84	112	478	84	112
Samantha,	630	112	140	554	112	140
Red III.,	553	84	140	560	84	140
Ida,	435	84	112	477	81	108
Totals,	2,162	364	504	2,069	361	500
Average per cow daily,	18.41	3 25	4.5	18.47	3.22	4.46
Experiment III.						
Samantha,	544	84	140	559	84	140
Red III.,	531	84	140	503	84	140
Ida,	448	84	112	445	84	112
May Rio,	560	84	112	553	84	112
Totals,	2,083	336	504	2,060	336	504
Average per cow daily,	18.60	3.00	4.50	18.39	3.00	4.50

It will be seen from the footings and averages of the above tables that the average basal ration in each half of each experiment consisted of like amounts of hay and bran, to which were added like amounts of either corn meal or ground oats. Hence a definite amount of corn meal was compared with a like amount of ground oats.

In the first experiment the dry matter in the corn meal and in the oats showed comparatively slight variation. In the second experiment, however, the corn meal averaged 85.37 per cent. and the oats 90.78 per cent. of dry matter, so that 3.84 pounds of dry matter in corn meal were fed against 4.05 pounds in oats. In case of the third experiment 3.8 pounds of dry matter in corn were fed against 4.02 pounds of dry matter in oats. This matter was overlooked at the time, but should have been guarded against by feeding slightly more corn meal. The difference, however, while in favor of the oats was not so great as to have caused a marked effect upon the yields of milk, and would be more than offset by the variations in the hay consumed by the several animals as indicated in the above tables.

Dry and Digestible Matter in Daily Rations (Pounds).

Experiment I.

CHARACTER OF RATION.	Average Weight per Cow.	Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.					Nutritive Ratio.
			Protein.	Fiber.	Extract Matter.	Fat.	Total.	
Corn meal, . .	877	21.61	1.63	3.40	9.63	.57	15.23	1: 8.76
Oat, . . .	891	24 70	1.81	3.53	8.74	.52	14.60	1: 7.41
Experiment II.								
Corn meal, . .	901	23.77	1.64	3.46	9.06	.56	14.73	1: 8.39
Oat, . . .	897	23.22	1.79	3.44	8.05	.49	13.76	1: 7.02
Experiment III.								
Corn meal, . .	863	23.09	1.54	3.27	8.91	.56	14 27	1: 8.71
Oat, . . .	880	23.12	1.72	3.36	8 08	.50	13.66	1: 7.29

The total dry matter fed in the first experiment was practically identical for each ration. In the second experiment the cows averaged .55 pound more dry matter per day on the corn meal ration. This was due to the fact that cows Minnie and Samantha ate more hay while receiving the corn meal. In the third experiment the amounts of total dry matter consumed were about the same. The average amount of digestible organic matter received by each cow was from about .6 to 1 pound less per day on the oat ration, due generally to the less digestible matter in the oats, and in case of the second experiment to the less hay eaten by the two cows mentioned.

The corn ration had a wider nutritive ratio than the oat ration, due to the less protein and more carbohydrate material in the corn.

Gain or Loss in Live Weight (Pounds).

Character of Ration.	Experiment I.	Experiment II.	Experiment III.	Total Gain.
Corn meal,	69+	36+	57+	162
Oat,	85+	24−	75+	136

The above figures indicate that a gradual gain in live weight took place, particularly during the first and third experiments. In the second experiment the gain was not so noticeable and, in fact, the animals lost slightly on the oat ration. One notes, however, no particular influence of one ration over the other.

Yield of Milk and Milk Ingredients (Pounds).

Experiment I.

Character of Ration.	Total Milk.	If Corn Ration equals 100, Oat Ration equals —	Total Solids.	Total Fat.
Corn meal,	2,293.4	-	325.3	125.3
Oat,	2,146.3	93.6	302.3	118.5
Experiment II.				
Corn meal,	1,991.7	-	294.3	115.1
Oat,	2,014.2	101.2	295.1	115.6
Experiment III.				
Corn meal,	2,150.1	-	316.3	127.5
Oat,	2,234.1	104.0	324.9	131.8
Average.				
Corn meal,	2,148.4	-	312.0	122.5
Oat,	2,131.5	99.0	307.0	122.0

In the second and third experiments the yields of milk and milk ingredients were nearly identical; at least, no marked variations were noted. In the first experiment the corn meal ration apparently produced the larger yield. This, however, was due in a large measure to the fact that the cow Minnie injured a teat shortly after starting in on the oat ration, and her milk yield fell some 5 pounds per day. The most that can be said is that an average of the three trials shows the two rations to have produced substantially like results. This was at first thought hardly to be expected, for the reason that the oats contain some 30 per cent. of hull, and, other things being equal, are rated as having an inferior feeding value to the corn. It is believed that the experiments were not conducted in such a way as to bring out sharply the difference in the value of the two feeds. The animals were evidently receiving an excess of nourishment, so that the mere difference in the nutritive value between 5 pounds of corn and oats was of no particular moment. If the amount of hay and bran (basal ration) fed had been noticeably less, so that the animals would have received in addition to their maintenance requirements perhaps three-fourths of the amount of food necessary for their normal milk yield, the addition of the corn meal or oats would have given a sharper indication of their respective nutritive values.

On the basis of the method suggested by Armsby,[1] allowing .5 pound of protein and 6 therms of energy for maintenance, .05 pound of protein and .3 therm of energy per pound of 4 per cent. milk, the average cow in the three experiments required and received as follows: —

Required.

CHARACTER OF RATION.	Average Weight of Cow (Pounds).	Average Milk Yield per Cow (Pounds).	Protein (Pounds).	Energy in Therms.
Corn meal, ...	880	19.2	1.40	11.10
Oat, ...	890	19.0	1.39	11.00

Received.

Corn meal, ...	880	19.2	1.60	12.42
Oat, ...	890	19.0	1.77	11.80

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[1] Farmers' Bulletin No. 346, p. 16.

The required nutrients were figured on the basis of average milk testing 4 per cent., while the average milk produced by the cows under test was 5.71 per cent. fat. Such milk would naturally require more nutrients for its production, but we have no exact method at present on which to base a calculation for milk of different degrees of richness. On the basis of the above calculations it will be seen that both the rations fed were in excess of those required, which, as above explained, would account for the lack of any particular difference in feeding effect.

The amount of digestible nutrients consumed by the *average cow,* and the amount required by Haecker's standard, was as follows: —

Nutrients consumed (Pounds).

Character of Ration.	Protein.	Carbohydrates, and Fat multiplied by 2.2.	Total.
Corn meal,	1.60	13.82	15.42
Oat,	1.77	12.84	14.61

Haecker Standard.

Character of Ration.	Protein.	Carbohydrates, and Fat multiplied by 2.2.	Total.
Corn meal,	1.74	12.37	14.11
Oat,	1.74	12.39	14.13

It will be seen that the digestible nutrients fed in each case were noticeably above what was required.

All of the above evidence goes to show that in case of both rations the cows received more than was actually needed, which, in itself, is a reasonable explanation of why the corn did not show itself superior in nutritive effect to the oats.

Average Composition of the Herd Milk.

Experiment I.

Character of Ration.	Total Solids (Per Cent.).	Fat (Per Cent.).
Corn meal,	14.18	5.46
Oat,	14.09	5.52

Average Composition of the Herd Milk — Concluded.

Experiment II.

Character of Ration.	Total Solids (Per Cent.).	Fat (Per Cent.).
Corn meal,	14.78	5.78
Oat,	14.65	5.74

Experiment III.

Corn meal,	14.71	5.93
Oat,	14.54	5.90

Net Amount of Dry and Digestible Organic Matter Required to produce Milk, Milk Solids and Fat.[1]

Experiment I.

	100 Pounds Milk.		1 Pound Solids.		1 Pound Fat.	
	Corn Ration.	Oat Ration.	Corn Ration.	Oat Ration.	Corn Ration.	Oat Ration.
Dry matter,	68.65	71.84	4.77	5.10	12.44	13.25
Digestible organic matter,	41.55	39.91	2.89	2.83	7.52	7.35

[1] Excluding food of maintenance.

Experiment II.

Dry matter,	71.19	68.32	4.80	4.62	12.46	11.86
Digestible organic matter,	43.24	37.84	2.91	2.56	7.55	6.55

Experiment III.

Dry matter,	65.33	62.25	4.39	4.23	10.87	10.41
Digestible organic matter,	39.54	34.36	2.66	2.33	6.58	5.74

Average.

Dry matter,	68.39	67.47	4.65	4.65	11.92	11.84
Digestible organic matter,	41.44	37.37	2.82	2.57	7.22	6.55

The above was calculated on the basis of Haecker's data, allowing 1.25 pounds of dry matter and .792 pound of digestible organic matter per 100 pounds live weight for maintenance.

The amount of total dry and digestible matter consumed was secured from our dry-matter determinations and analyses and the use of average digestion coefficients. They tell substantially the same story as did the yields of milk and milk ingredients. In the first experiment it required rather more dry matter to produce a definite amount of milk and milk ingredients with the oat ration. In all of the experiments a definite amount of milk and milk ingredients was produced by a little less digestible matter derived from the oat ration. The average of the three trials shows milk and milk ingredients were produced by the use of rather less dry and digestible matter for the oat ration. The reason for this has already been indicated.

Food Cost of Milk and Butter-fat.

Experiment I.

Character of Ration.	Total Milk.	100 Pounds Milk.	1 Quart Milk (Cents).	1 Pound Fat (Cents).
Corn meal,	$30 91	$1 35	3.04	24.7
Oat,	32 26	1 50	3.38	27.2
Experiment II.				
Corn meal,	$30 09	$1 51	3.40	26.1
Oat,	30 62	1 52	3.42	26.5
Experiment III.				
Corn meal,	$29 07	$1 35	3.04	22.8
Oat,	30 30	1 36	3.06	23.0
Average.				
Corn meal,	$30 02	$1 40	3.16	24.5
Oat,	31 06	1 46	3.29	25.6

In the first experiment the milk cost noticeably less on the corn ration; in the second experiment the results were about equal; and in the third experiment the corn ration had a slight advantage. The average of the three experiments is slightly in favor of the corn ration. The reason for sharper difference between the influence of the two rations has already been explained. In this experiment hay was figured at $16, corn meal at $32, oats at $37.50 and bran at $26 a ton.

CONCLUSIONS.

1. Chemical analysis and digestion tests indicate that oats have about one-fourth less actual nutritive value than corn (on basis of equal parts of dry matter).

2. The three comparative experiments conducted with dairy cows indicated that the oat ration produced practically as much milk and butter as did the corn ration, but at 3½ per cent. greater cost.

3. The reason why the difference in the nutritive effect of the two grains was not more sharply brought out probably lies in the fact that the experiments themselves were not correctly planned. The nutritive material in the total oat ration was sufficient to enable the cows to do good if not maximum work, and the increased nutritive material in the corn ration was not necessary and had, therefore, no pronounced effect. The basal ration (*i.e.*, without the corn or oats) should have been less in amount and then the results obtained from the addition of corn and oats would have been more pronounced.

4. Many experiments to compare the practical feeding values of different feedstuffs do not return the results desired, for the reason that they are not planned in a way to eliminate all but the one point to be demonstrated. In fact, it is not believed that experiments of this character can tell as true a story as investigations resulting from analysis, digestibility and respiration experiments, when the net energy values of the several feedstuffs can be fairly accurately ascertained. Experiments however, of the sort here described are useful in giving one a general idea of the relative merits of different feeding stuffs, but care should be taken to keep the basal ration considerably below the amount of food needed, so that when the feeds to be studied are added the total ration will still be a little below the amount required by the animal for an average production.

5. While oats are a valuable food, it is not believed they can usually be fed economically to dairy animals in Massachusetts.

SOME EFFECTS OF FERTILIZERS ON THE GROWTH AND COMPOSITION OF ASPARAGUS ROOTS.

FRED W. MORSE.

A series of fertilizer experiments on asparagus was planned in 1906 by Director Brooks, to ascertain the efficiency of different methods of manuring this crop. The field is located on the farm of Mr. C. W. Prescott in Concord, and its soil is like that of most asparagus fields, a sandy loam of little natural fertility.

In January, 1910, the writer was assigned the task of ascertaining the specific effects of the three principal chemical fertilizers used in the experiment — nitrate of soda, acid phosphate and muriate of potash — on the chemical composition of the crop, as such effects would be important factors in determining the relative efficiency of the fertilizers.

This paper will deal with the effects of the fertilizers upon the roots of the asparagus plants, a matter about which little has been reported by other workers.

Rousseaux and Brioux made a partial analysis of the roots as a minor part of an elaborate research on the asparagus crop published in 1906.[1]

Tanret has made an extended study of the properties of the carbohydrates contained in the roots.[2]

Wichers and Tollens have reported very complete analyses of roots collected before and after the cropping season.[3]

The material studied by the writer consisted of the entire underground portion of the asparagus plant, except the fine, fibrous feeding-rootlets which were removed, as it was impossible to collect any reasonable proportion of them.

No effort was made to separate the crown or center of the plant from the fleshy roots. The plants were selected by the size of their tops, and the effort was made to get average plants for each type of fertilization. The plants were carefully excavated, and as nearly as possible all the fleshy roots were collected. In some instances growth had been so extensive that adjacent roots were much interlaced, and it was impossible to secure one plant without destroying all others around it. Therefore, our largest, heaviest roots were more or less incomplete.

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[1] Annales de la Science Agronomique, 3d Series, I., pp. 189-326 (1906).

[2] Bulletin de Soc. Chim. (4) V., pp. 889-893 (1909); Compt. Rend. 149, p. 48 (1909).

[3] Jour. fur Landwirthschaft 58, pp. 101-112 (1910).

On the day following the collection of the specimens the roots were shipped from Concord to the experiment station, where they were placed in a cool cellar. The process of washing free from soil, weighing when free from surface moisture, drying and grinding, was very laborious and required several weeks, owing to the weight and bulk of the material. There is always danger of respiratory changes during the period of preparation, between collecting and drying; but it is believed that they were reduced to a minimum by keeping the roots in a cool place at about 10° C. Washing was performed within a few days after digging, and the weights of the fresh roots were obtained before there could have been any respiratory losses.

The material was prepared for drying by passing the crown and roots through a hand-lever fodder-cutter by which they were cut into pieces about 2 centimeters in length. Drying was done in a large oven at a temperature between 50° and 60° C., and the material was dried until sufficiently brittle to be easily ground. The weight of the specimen was taken at this stage, and then the entire lot was coarsely ground in a drug-mill, after which it was sampled by quartering and the sample reduced to a powder which would pass though a 1 millimeter mesh sieve. Moisture determinations were then made in the powdered samples, from which were calculated the weights of absolutely dry matter contained in the specimen roots.

Three different series of samples have been studied during this investigation.

The first series consisted of 44 roots, or 4 specimens from each of 11 plots, used for testing different quantities and different seasons of application of nitrate of soda. They were collected in November, 1908, two years after the field had been set with plants, by Mr. E. F. Gaskill of the agricultural department of the experiment station, and were prepared for analysis in part by the fertilizer section and in part by the feed and dairy section of the department of chemistry.

The second series consisted of 76 roots, or 4 from each of 11 nitrogen plots before mentioned, together with 4 plots used for a test of different quantities of superphosphate and 4 plots for different quantities of muriate of potash. These samples were secured by Mr. Gaskill and the writer in November, 1910, and were prepared for analysis under the supervision of the latter.

The third series consisted of 16 roots, or 4 from each of 4 of the nitrogen plots, and were gathered under the supervision of Mr. C. W. Prescott on June 23, 1911, and were prepared for analysis by the writer.

All the analytical work has been based on the methods of the Association of Official Agricultural Chemists,[1] except where departures are mentioned as necessary owing to the character of the material.

Amount of Fertilizers applied.

Each plot in these tests contained one-twentieth acre and was 129 feet long by 16 feet 10½ inches wide. At the time of setting the plants the entire area received a uniform dressing of the following chemical fertilizers: —

	Pounds per Acre.
Lime,	2,000
Fine-ground bone,	1,000
Nitrate of soda,	150
Acid phosphate,	600
Muriate of potash,	350

No check plots without fertilizer were included in the plan.

The annual top-dressing was applied to the different plots in the following quantities per acre: —

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[1] Bulletin No. 107 Revised, Bur. of Chem., U. S. Dept. of Agr.

	Plot Number.	Nitrate Soda (Pounds).	Acid Phosphate (Pounds).	Muriate Potash (Pounds).
No nitrate,	1, 40	–	200.1	260.0
Low nitrate,	31, 32, 33	311.2	200.1	260.0
Medium nitrate,	34, 35, 36	466.6	200.1	260.0
High nitrate,	37, 38, 39	622.4	200.1	260.0
No phosphate,	5	466.6	–	260.0
Low phosphate,	6	466.6	133.4	260.0
Medium phosphate,	7	466.6	200.1	260.0
High phosphate,	8	466.6	266.8	260.0
No potash,	9	466.6	200.1	–
Low potash,	10	466.6	200.1	173.4
Medium potash,	11	466.6	200.1	260.0
High potash,	12	466.6	200.1	346.8

The nitrate of soda was applied to plots 31, 34 and 37 in the spring before growth began; to plots 32, 35 and 38 in the summer after cutting had ceased; and to plots 33, 36 and 39, one-half in spring and one-half in summer. All phosphate and potash salts were applied in the spring.

Effect of Fertilizers on the Weight of Roots.

Since the marketable crop from the asparagus plant must be grown almost entirely at the expense of the reserve plant food stored in the crown and roots, the size of the roots at the beginning of the growing season would seem to be an important factor in the yield of sprouts. While their relationship has not yet been determined, it has been noted that the different top-dressings influenced the size of the roots to a marked extent.

The effects of nitrate of soda have been observed in all three series of samples, but only one series has afforded an opportunity to study the effects of phosphates and of potash salts. Nevertheless, the series gathered in 1910 was at the end of the fourth season of growth, and hence should have the cumulative effect of three annual dressings.

Effect of Different Amounts of Nitrate of Soda.

Season of 1908, Average Roots.

	Plot Number.	Fresh Weight (Grams).
No nitrogen,	1, 40	1,027
Low nitrogen,	31, 32, 33	947
Medium nitrogen,	34, 35, 36	1,248
High nitrogen,	37, 38, 39	1,127

Season of 1910, Average Roots.

	Plot Number.	Fresh Weight (Grams).
No nitrogen,	1, 40	2,128
Low nitrogen,	31, 32, 33	2,362
Medium nitrogen,	34, 35, 36	2,703
High nitrogen,	37, 38, 39	2,464

Season of 1911, Average Roots.

	Plot Number.	Fresh Weight (Grams).
Low nitrogen,	31, 32	2,259
Medium nitrogen,	34, 35	2,555

It is noted that the medium application of nitrate of soda has produced the heaviest average roots in each season.

Effect of Phosphate and Potash Salts.

Season of 1910, Average Roots.

	Plot Number.	Fresh Weight (Grams).
No phosphate,	5	1,783
Low phosphate,	6	2,853
Medium phosphate,	7	2,735
High phosphate,	8	2,246
No potash,	9	1,674
Low potash,	10	2,395
Medium potash,	11	2,893
High potash,	12	2,709

In spite of the large application of bone, acid phosphate and muriate of potash at the time of setting the plants, the absence of either in the top-dressing produces a notably lower average weight of roots. The medium applications of phosphate and of potash salts produce the highest average weights of roots.

Rousseaux and Brioux[1] found the heaviest roots where manure and chemicals were combined, and it is of interest that the fresh weight was 2,600 grams, which is practically the same as the weight of our roots from the plots receiving top-dressings of medium amounts of fertilizers.

Effect of Season of Application of Nitrate of Soda on Weight of Roots.

Spring Application (Grams).

	Plot Number.	1908.	1910.	1911.
Low,	31	1,025	2,545	1,852
Medium,	34	1,260	2,733	2,776
High,	37	1,336	2,854	–
Average,	–	1,207	2,711	2,314
Summer Application (Grams).				
Low,	32	923	2,004	2,666
Medium,	35	1,274	2,289	2,335
High,	38	1,302	2,311	–
Average,	–	1,166	2,201	2,501
Spring and Summer Applications (Grams).				
Low,	33	895	2,538	–
Medium,	36	1,211	3,089	–
High,	39	730	2,227	–
Average,	–	915	2,618	–

The summer top-dressing with nitrate has produced smaller mature roots than the spring top-dressing, in both years 1908 and 1910. On the other hand, the roots of 1911, taken at the end of the cutting season in the summer, show variable results, with the average weight heavier on the summer-dressed plots.

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[1] *Loc. cit.*, p. 312.

The individual roots in this summer collection showed much wider variations than the late fall series, which is attributed to the difficulty of judging average plants by the young shoots, and it is probable that the different plots are not as fairly represented as in the fall collections.

EFFECT OF FERTILIZERS ON THE FERTILIZING CONSTITUENTS OF THE ROOTS.

The fertilizing constituents of asparagus roots were found by Rousseaux and Brioux[1] to be as follows: —

	Manure only (Per Cent.).	Manure and Chemicals (Per Cent.).
Dry matter,	28.26	26.27
Ash,	6.90	7.22
Nitrogen,	1.20	1.73
Phosphoric acid,	.50	.48
Potash,	1.23	1.57
Lime,	.31	.41
Magnesia,	.04	.05
Sulfuric acid,	.33	.36

Wichers and Tollens[2] reported the following results on the principal fertilizing constituents: —

	Roots (Per Cent.).	Crown (Per Cent.).
Moisture,	3.00	3.86
Nitrogen,	2.26	1.64
Phosphoric acid (P_2O_5),	.89	.54
Potash (K_2O),	1.44	1.60

The general average of fertilizing constituents calculated from the various analyses made at this experiment station is as follows: —

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[1] *Loc. cit.*, p. 312.

[2] *Loc. cit.*, p. 109.

	Per Cent.
Dry matter,	21.68
Ash,[1]	6.56
Nitrogen,	1.95
Phosphoric acid (P_2O_5),	.48
Potash (K_2O),	2.36
Lime (CaO),	.34
Soda (Na_2O),	.30
Magnesia (MgO),	.17
Sulfuric acid (SO_3),	.56

An interesting fact shown by this table is the higher average percentage of sulfuric acid over that of phosphoric acid. The proportions of fertilizing constituents were varied somewhat by the applications of different quantities of the chemical fertilizers, as is usually observable in similar experiments with crops.

Effect of Nitrate of Soda on Ash Constituents.

Roots of 1908.

	No Nitrate, Plots 1 and 40.	Low Nitrate, Plots 31, 32, 33.	Medium Nitrate, Plots 34, 35, 36.	High Nitrate, Plots 37, 38, 39.
Ash,	5.73	6.40	6.69	6.59
Phosphoric acid,	.47	.53	.47	.51
Potash,	2.27	2.33	2.46	2.54
Lime,	.30	.28	.32	.34
Soda,	.07	.20	.27	.26
Magnesia,	.13	.14	.15	.15
Sulfuric acid,	.39	.48	.52	.52

Effect of Superphosphate on Ash Constituents.

Roots of 1910.

	No Phosphate, Plot 5.	Low Phosphate, Plot 6.	Medium Phosphate, Plot 7.	High Phosphate, Plot 8.
Ash,	6.81	7.09	7.54	7.34
Phosphoric acid,	.47	.46	.46	.49
Potash,	2.36	2.66	2.73	2.54
Lime,	.41	.32	.37	.38
Soda,	.43	.35	.38	.33
Magnesia,	.18	.16	.21	.19
Sulfuric acid,	.69	.62	.68	.63

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[1] Ash determinations and all ash analyses were made in the fertilizer section by Mr. H. D. Haskins and Mr. L. S. Walker.

Effect of Muriate of Potash on Ash Constituents.

Roots of 1910.

	No Potash, Plot 9.	Low Potash, Plot 10.	Medium Potash, Plot 11.	High Potash, Plot 12.
Ash,	5.94	6.17	6.18	7.10
Phosphoric acid,	.44	.42	.46	.48
Potash,	1.44	2.10	2.20	2.53
Lime,	.38	.33	.34	.40
Soda,	.55	.48	.33	.33
Magnesia,	.19	.18	.19	.20
Sulfuric acid,	.66	.57	.62	.62

The presence or absence of phosphoric acid in the top-dressing produces little or no perceptible effect on the ash and ash constituents, even the phosphoric acid percentages being remarkably uniform throughout the whole series of tests. The absence of nitrate of soda and muriate of potash reduces the percentages of ash, and in the former case the soda and sulfuric acid are reduced also, while in the latter case it is the potash which is reduced. Lime and magnesia are apparently unaffected by the variations in top-dressings.

EFFECT OF FERTILIZERS ON THE NITROGEN AND NITROGENOUS RESERVE MATERIAL.

The nitrogenous matter stored in the roots was definitely affected by the different quantities of nitrate of soda applied. and also by its season of application; but the superphosphate and muriate of potash had no effect on the percentage of this element.

Effect of Nitrate of Soda on Nitrogen.

	Plot Number.	1908 (Per Cent.).	1910 (Per Cent.).
No nitrate,	1, 40	1.28	1.53
Low nitrate,	31, 32, 33	1.69	1.82
Medium nitrate,	34, 35, 36	2.10	1.97
High nitrate,	37, 38, 39	2.10	2.05

Effect of Superphosphates on Nitrogen.

	Plot Number.	1910 (Per Cent.).
No phosphate,	5	2.27
Low phosphate,	6	2.05
Medium phosphate,	7	2.18
High phosphate,	8	2.04

Effect of Muriate of Potash on Nitrogen.

	Plot Number.	1910 (Per Cent.).
No potash,	9	2.10
Low potash,	10	2 02
Medium potash,	11	2.06
High potash,	12	2.08

Effect of Season of Application of Nitrate of Soda on the Nitrogen.

Spring Application.

	Plot Number.	1908 (Per Cent.).	1910 (Per Cent.).
Low,	31	1.57	1.64
Medium,	34	2.18	1.97
High,	37	1.96	1.96
Average,	–	1.90	1.86

Summer Application.

	Plot Number.	1908 (Per Cent.).	1910 (Per Cent.).
Low,	32	1.78	1.99
Medium,	35	2.23	2.01
High,	38	2.36	2.22
Average,	–	2.12	2.07

Spring and Summer Applications.

	Plot Number.	1908 (Per Cent.).	1910 (Per Cent.).
Low,	33	1.73	1.82
Medium,	36	1.92	1.94
High,	39	1.98	1.98
Average,	–	1.88	1.91

The higher percentage of nitrogen due to the summer top-dressing with nitrate of soda is very noticeable, as was the smaller average weight of roots, compared with the spring application.

The roots of 1911 gathered in the summer just before the annual summer top-dressing showed the same general differences between the spring top-dressing and summer top-dressing.

Spring Application.

Plot Number.	Per Cent.
31,	1.81
34,	2.05
Average,	1.93

Summer Application.

Plot Number.	Per Cent.
32,	2.06
35,	2.15
Average,	2.10

Whatever exhaustion of material occurred during the cutting season did not influence the percentages of nitrogen in the roots.

EFFECT OF FERTILIZERS ON THE NON-NITROGENOUS MATERIAL OF ASPARAGUS ROOTS.

Wichers and Tollens[1] have shown the proximate composition of asparagus roots and crowns to be as follows: —

	April.		July.	
	Roots.	Crowns.	Roots.	Crowns.
Moisture,	3.00	3.86	3.61	2.93
Ash,	12.20	15.21	11.77	11.67
Crude protein,	14.13	10.25	16.56	9.90
Crude fiber,	8.72	15.42	13.54	19.79
Fat,	.72	1.59	1.10	1.67
Nitrogen-free extract,	61.23	53.67	53.42	54.04
	100.00	100.00	100.00	100.00
Sugar,	36.80	17.70	23.19	15.32
Pentosans,	6.25	9.77	7.73	11.48

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[1] *Loc. cit.*, p. 109.

The writer has found the composition of the combined crowns and roots in his samples to average as follows: —

	November, 1908, 16 Roots.	November, 1910, 4 Roots.	June, 1911, 8 Roots.
Dry matter,	-	22.40	18.34
Ash,	6.24	7.68	8.87
Crude protein,	11.03	11.02	12.75
Crude fiber,	15.39	17.89	23.66
Fat,	1.00	1.58	1.63
Nitrogen-free extract,	66.34	61.83	53 09
	100.00	100.00	100.00
Sugar,	41.43	35.85	20.87
Pentosans,	8.78	10.12	11.66

The sugar which forms such an important percentage of the reserve material has been found to be a soluble carbohydrate readily hydrolyzed to glucose and fructose, having a rotary power differing widely from cane sugar, but otherwise resembling it in all its chemical properties.[1]

In the series of 1910 and that of 1911 particular attention was paid to the sugar to determine if fertilizers had any effect on its development.

The sugar was extracted by heating 2 grams of the dry, finely powdered material with 50 cubic centimeters of water in the boiling water bath. Basic lead acetate and alumina cream were added after the solution was cool, and the volume made up to 100 cubic centimeters. When the precipitate had settled, which it usually did in an hour, the solution was filtered through a dry filter. The lead was then removed with sodium carbonate and an aliquot of 50 cubic centimeters was inverted by HCl by standing for twenty-four hours at 20° to 25° C.

About half of the samples showed the presence of reducing sugars before inversion, but seldom more than a trace; the remainder showed no presence of reducing sugars

The total invert-sugar was determined by use of Fehling's solution in the usual manner, and the copper was determined volumetrically.

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[1] Tanret, *loc. cit.*; Wichers and Tollens, *loc. cit.*; Morse, Jour. Am. Chem. Soc., 33, 211–215.

In the nitrogen series the sugar was determined in each root and then averaged for the plot as in the nitrogen investigation, but in the superphosphate and potash series only two roots from each plot were used.

Effect of Nitrate of Soda on Sugar.

	Plot Number.	1910 (Per Cent.).	1911 (Per Cent.).
No Nitrate.			
	1	29.80	-
	40	37.41	-
Low Nitrate.			
Spring application,	31	35.76	25.76
Summer application,	32	29.79	13.30
Spring and summer application,	33	31.85	-
Medium Nitrate.			
Spring application,	34	34.56	27.84
Summer application,	35	38.56	25.90
Spring and summer application,	36	31.59	-
High Nitrate.			
Spring application,	37	35.48	-
Summer application,	38	36.04	-
Spring and summer application,	39	34.43	-

Effect of Superphosphate and Muriate of Potash on Sugar.

	Plot Number.	1910 (Per Cent.).
No phosphate,	5	26.02
Low phosphate,	6	25.89
Medium phosphate,	7	28.05
High phosphate,	8	24.86
No potash,	9	28.72
Low potash,	10	32.56
Medium potash,	11	32.10
High potash,	12	34.79

The percentages of sugar vary independently of the various kinds of top-dressing, since there are wide variations in the results for Plots 7, 11 and 34, on which identical amounts of fertilizers had been applied.

The season of application of nitrate of soda apparently did not influence the percentages of sugar in the fall roots, but there is less apparent exhaustion in the 1911 roots where nitrate had been applied in the spring (Plots 31 and 34).

Since the variations in sugar showed so little relationship to the scheme of fertilization, it was not deemed worth while to pursue the investigation into the effects upon fiber and pentosans, as there are too many factors to be correlated.

Summarizing the results briefly, it has been shown that the medium amounts of chemicals in this series of fertilizer tests produced the most favorable results on size and composition of the asparagus roots.

The absence of any one of the three fertilizers resulted in depression of weight of root, which was accompanied by a depression in nitrogen in the absence of nitrate of soda, and by a depression in the potash and ash in the absence of muriate of potash.

The summer top-dressing with nitrate of soda produced smaller roots than the spring top-dressing, but with notably higher percentages of nitrogen. The exhaustion of the roots by the cropping season was most manifest in the percentages of sugar in the roots from the summer top-dressed plots.

The thanks of the author are due Messrs. Haskins and Walker for the analytical data on ash and ash constituents, to Dr. W. P. Brooks, director, for the fertilizer data, and to Dr. J. B. Lindsey, chemist, for many timely suggestions.

DEPARTMENT OF ENTOMOLOGY.

REPORT OF THE ENTOMOLOGIST.

H. T. FERNALD.

During the year 1912 the work in the department of entomology has been mainly devoted to the prosecution of projects already begun, with few additions to the list.

The insect collection has been somewhat added to and maintained in its previous good condition. Its constant use for reference by every one working on insects at the college, and by many from outside, has been very noticeable, and its value for this purpose is constantly increasing as it becomes more complete.

The number of letters of inquiry received during the year has been so large as to require, on an average, several hours' attention each day, and, as was the case last year, has covered many topics. Most of these inquiries have not been about the more noticeable insects, but about what may be termed those of secondary prominence, for though destructive they are not as liable to attract attention. As less is naturally known about these insects than about the more evident ones, more time has necessarily been required to give the information desired than was the case a few years ago, and in some instances personal visits have been required in order to fully understand conditions before the best advice as to treatment could be given.

Under the Hatch act further observations on the dates of hatching of the young of the oyster-shell, pine-leaf and scurfy scales have been made, and experiments on the control of the onion maggot have been begun. These last are reported on more fully elsewhere. Tests of various insecticides have been made and are also reported elsewhere. Methods for the protection of seed corn from wireworms have been continued, and an improvement on those previously discovered is now under consideration for next season.

Under the Adams fund the two projects mentioned in former reports have been carried farther. The causes of the burning of foliage by arsenical poisons have been given much study, accompanied by over a thousand separate field tests, each followed by an examination of the results of the treatment at intervals of a day or two for more than a month. Closely involved in this has been the consideration of the nature of the insecticides used, and in this portion of the work the co-operation of the chemical department of the station has been invaluable.

If the causes of injury to foliage following the application of arsenicals are to be clearly understood, it is evident that the composition of the materials applied must be known. The injury may in fact be due, either to impurities in the materials themselves, to their decomposition after application to the leaves, or to something normally and necessarily present in them. To avoid the first possibility, materials as nearly absolutely pure as it is possible to obtain have been sought, and have only been found after many trials, it being evident that almost none of the insecticides on the market at the present time are pure or even anywhere near it. As it is quite possible that the impurities are the cause of the injuries, it is of course desirable to eliminate these, and in the materials used the first season it was supposed that this had been accomplished. Too late it was learned that this was not the case, and that the treatment was made with substances which had been guaranteed pure by the manufacturers, but which were far from being so. The consequence was that the chemical department was obliged to take up the problem of finding methods by which pure Paris green, arsenate of lead and arsenate of lime could be made, and of providing this department with them in quantities sufficient for use. This has been successfully accomplished, and the spraying last year, in part, and the past summer has been with these.

The actual value of wasps as parasites has never been investigated carefully. General statements that they are "extremely useful," or that "their importance can hardly be overestimated," are in reality little more than guesses, and it has seemed desirable to investigate the subject more scientifically in order to determine their real efficiency. To do this with all wasps is of course impossible, so a group of these insects widely distributed in all parts of the country has been selected for study. To clear the way and establish a firm foundation for the work it has been necessary to ascertain how many kinds are involved, and their relative abundance in different localities, to be followed by a determination of their fertility, the nature and amount of the food they consume, their mortality and numerous other factors which enter into the problem. Most of the preliminary work on this project has now been completed, and considerable has been accumulated on its other aspects. It is too soon to generalize on this subject, but it has already become evident that these insects are decidedly beneficial because of their choice of food material which is in most cases chosen from among our worst pests.

The results of experimentation on color vision in bees — an Adams fund project in charge of the apiarist of the station — are stated as follows: —

> While much limited in time available for the several branches of bee-keeping work this year, progress in experimentation on the color vision of bees has been made. One supposition has been proven with relative satisfaction. An instrument for counting has been devised and relatively perfected. A foreign work which applies to the problem has been translated. Correlated experiments have given and are giving good results.

So far as opportunity has offered, studies on the distribution of our worst pests in the State have been continued and the results tabulated for future reference.

Other work of the department is more fully detailed elsewhere in this report under the titles, "Tests of Insecticides," "Experiments for the Control of the Onion Maggot" and "Insect Record for 1912 in Massachusetts."

EXPERIMENTS FOR THE CONTROL OF THE ONION MAGGOT.

H. T. FERNALD AND A. I. BOURNE.

Onions are grown on a large scale in many parts of Massachusetts, particularly in the Connecticut valley. Fields covering 10, 15 or even 25 acres are common, and the crop is an important one.

For some years the onion maggot, *Phorbia ceptorum* Meade, has been a serious enemy of the onion grower in this region, much loss having been caused by its ravages. In 1911 this was particularly the case, one individual who had 6 acres planted estimating his loss by the attacks of this insect at about $400. Quite a part of this was on one plot covering only 2 acres, which was so thoroughly infested as to make the crop there hardly worth gathering. It has seemed desirable on this account to investigate methods for the control of the onion maggot, particularly as applied to large fields.

The Problem.

1. To determine the effectiveness of various methods for the control of the onion maggot.

2. To determine whether any which prove effective can be used in large fields without too great cost.

Previous Experiments.

An examination of the literature on this subject showed that most of the work had been primarily with other maggots such as the cabbage maggot, *Pegomyia brassicae* Bouché, and that conclusions had apparently to a large extent been drawn from these experiments. Where this was not the case it seemed probable from what was stated that the tests had been made upon but a few rows of onions at most.

To regard methods of controlling the cabbage maggot as equally applicable to the onion maggot is a rather doubtful position to take. Cabbages are grown from seed under glass or screens, and when they have arrived at the proper size are transplanted; and are usually placed about 2 feet apart. Onions (except for "sets") are planted where they are to remain until gathered, only an inch or two apart, and with the rows from 12 to 15 inches distant. Conditions, therefore, are widely different, especially when a large acreage is concerned.

With these facts in mind some of the treatments described could immediately be discarded as impracticable under the conditions existing, whether reported as of value or not. Others, it seemed, might possibly be made use of, — though the question of their cost for large fields would need to be determined, — while others, still, appeared on their face to be rather promising. A new substance, nicine, which had been received for trial was also included in the list of materials to test.

Conditions of the Experiment.

For experimental purposes on a rather small scale, preliminary to later, more extended ones, two plots of land were reserved close by where onions had been growing the preceding year, and where the maggots had been very abundant. Each was about 70 by 75 feet in dimensions. The north plot lay somewhat higher than the other, and the soil was somewhat sandy and lighter than that of the south plot, where it was rather heavy. Both plots sloped slightly toward the south, and the two were separated only by a grass roadway. In the north plot the onions were planted in rows about a foot and a half apart, while in the other they were only a little over a foot apart. In both plots the rows ran north and south.

The "catch" of the seed in neither plot was satisfactory. Gaps often a foot or two in length were frequent in the rows, particularly in the north plot, and this may have had some influence upon the results, as it is claimed that the maggots after destroying a plant may at least in some cases pass to the next one in the row. If this be correct, gaps in the row would tend to reduce the number of plants injured below what would be the case in full rows.

Treatment was begun soon after the plants appeared, when they were not more than an inch and a half high, and was continued at proper intervals until the maggots were seen to be leaving the plants to pupate. At the time of the first treatment no trace of maggots or of flies laying eggs could be found. Each material was applied to specified rows in each plot. Between these, untreated rows — usually several — were reserved as checks.

The weather during the period the tests were made was, on the whole, quite favorable, there being little rain, and what there was, mainly in the form of light showers. In no case did rain follow an application so closely as to thereby much impair its effectiveness. Occasionally the wind was strong enough to cause a little difficulty in applying dusting materials, but in general the days were clear, warm to hot, and with little wind.

Examination of the results of each kind of treatment was made frequently, and all plants found infested were removed, care being taken to remove all the maggots at the same time, that they might not go to other plants and thereby increase the apparent infestation.

No exact record of the number of maggots found in any single plant was kept, but it was noticed that during the earlier part of the season there were usually but one or two maggots in each infested plant. Later, as the plants became larger, it was not uncommon to find 10 or 12, or even more, in a plant. Wireworms and white grubs were present, attacking the onions, but in very small numbers.

Experimental Work.

Examination of the records of work on this insect carried on elsewhere finally resulted in the selection of the following materials for trial: (1) carbon disulfid; (2) nicine; (3) powdered hellebore; (4) hellebore decoction; (5) soap wash; (6) carbolic acid and lime; (7) kerosene emulsion of three different strengths; (8) carbolic acid emulsion also of three different strengths. More detailed accounts of the use of each of these, and the results, follow: —

Carbon Disulfid. — This substance has been recommended as very effective. It is applied in shallow grooves near the plants, so that the gas into which it becomes converted may penetrate through the soil to the onions and destroy the maggots. The fluid itself, however, is liable to kill the plants if it reaches them.

In this experiment a shallow groove was made about 2 inches from each plant, and a little of the liquid was poured into this. The groove was then quickly covered. The application is rather slow and tedious, particularly if more than a small area is thus treated, as the grooves must be short, unless considerable material is wasted, in order to cover quickly.

This treatment proved to be very unsatisfactory. For some reason many of the plants were killed, indicating that either too much disulfid was applied; that the grooves were too near the plants; or that the gas as well as the liquid is dangerous to use. In this experiment about 90 per cent. of the plants died. On the other hand, a large proportion of the plants which escaped destruction by the treatment became infested with maggots, from which it may be concluded that where the application is so far from the plant or so little is used as to avoid injury no protection from maggots is obtained. It is possible that with an exact amount of material to apply to each plant carefully worked out, and the distance to apply this also known, protection without injury might be secured; but it is evident that such care in application as this would require would be impossible in the case of large fields, where the amount of time demanded to do it properly would make the cost prohibitive.

Even when not applied with the utmost care the cost is great. Carbon disulfid in small quantities costs about 30 cents per pound. It might, perhaps, be obtained in bulk for half this price, but taking the higher cost and calculating the amount necessary to treat 1 acre we would have an expenditure of from $12 to $14, while the time required to apply it to this area, based on wages at $1.75 per day, would be rather more than this, and if more care in the application were given the time would probably be more than doubled. The cost of using carbon disulfid per acre, therefore, allowing the material to be purchased at half what it actually cost for the experiments, would be at least from $20 to $30 per acre, — a prohibitive expense.

Nicine. — This substance, manufactured by the Hood Chemical Company of Chicago as a deodorant, disinfectant and germicide, was offered for trial as an insect repellant. It is a powder, and directions furnished by the company were as follows: —

> Where a plant or tree is infected with root maggots shake off as much of the earth from the roots as possible. Then sprinkle nicine over the roots and plant in fresh soil, and if convenient make a small circular ditch about 3 or 4 inches deep around the plant and 1½ to 2 feet from the center. Sprinkle nicine freely in this ditch, cover up with soil, and the plants will not be bothered with maggots or insects.

It was manifestly impossible to follow these directions in the case at hand. The nicine was therefore dusted along the rows, care being taken to place a good supply around the base of each plant. As the maggot must work down along the plant to the bulb, where it feeds, this method would seem to force the maggots to pass through, or at least close to, the powder, which has a very pronounced odor.

The result of this experiment was unsatisfactory, as plants in the rows treated became infested shortly after the application. In fact, some of the earliest infestations in the field were in rows treated in this way.

At such prices as have been quoted for this material, enough to treat an acre in this way would cost about $50, and the labor in applying it would cost about $12 or $13. Evidently, then, this material is not available for use on large onion fields, irrespective of its effectiveness, because of the expense which would be incurred.

Powdered Hellebore. — Ordinary powdered hellebore was dusted liberally along the rows around and over the bases of the plants, with the idea that the young maggots working down to the bulbs to feed would come in contact with it and be destroyed. It has been supposed that it might also act to some extent as a repellant, preventing egg laying.

Results from this treatment could at best be rated as only fair. The application was repeated three times, and this of course meant a large increase in cost. Hellebore in sufficient amount to treat an acre once would cost, at the rate paid for the material used in these tests, more than $50, and the labor in applying it about $13 more. Even if it were effective as a treatment its cost would, accordingly, prevent its use in large onion fields.

Hellebore Decoction. — This was prepared in accordance with directions given by Smith (New Jersey Bulletin No. 200), by steeping 2 ounces of powdered hellebore in a quart of water for half an hour, stirring occasionally. It was then diluted, to make 1 gallon of liquid, and applied thoroughly to the ground at the base of each plant. If a large amount of this decoction be made at one time it can be kept without losing strength if placed in tight containers.

This material was applied through a nozzle giving a coarse stream, only enough pressure being given to the pump to cause a steady flow, without breaking up the decoction into a spray. A liberal amount was placed at the base of each plant in this way. Three applications were made at about ten-day intervals.

Results obtained were very unsatisfactory, as the treatment did not seem to have any effect whatever on the infestation. Its cost, too, though less than that of the powdered hellebore, placed it as too expensive for use. Decoction sufficient for one application to an acre would cost about $15, while the expense of application would be about $12. Three treatments, therefore, would be prohibitive from this standpoint, though necessary, even according to those who report some success with this material.

Soap Wash. — This was made by dissolving 1 pound — about 2 bars, in most cases — of good soap in 10 gallons of water. It was poured along the rows, using a force pump without a nozzle so that a solid stream could be obtained, and the ground around the plants was well soaked with it. Three treatments were given at intervals of about ten days except in one case where rain seemed to make it desirable to repeat the application without waiting for the end of this period.

Results with this material were at best only moderately good, infection appearing to some extent along the rows treated in this way. As the cost of soap enough to cover an acre once in this way would be from $8 to $10, and the labor involved would come to about $14, three treatments, each costing from $20 to $24, would manifestly be too expensive.

Carbolic Acid and Lime ("Carbolized Lime"). — The object of this treatment is to cover the ground around each plant with a coating through which the maggots cannot penetrate, much as tarred paper discs act in the case of the cabbage maggot. The practical difficulty with it is that in cultivation and weeding the coating becomes broken and therefore not effective.

To prepare it, lime is slaked to a thick cream. Three pints of this are added to a gallon of water, and a tablespoonful of crude carbolic acid is stirred in. The mixture is then poured along the rows to form a complete coating around each plant.

The odor of the carbolic acid was very noticeable for some time near the plants treated in this way. It was necessary to repeat the treatment, however, after each cultivation or row weeding, as in every case the coating was more or less broken by this work.

The results were far from satisfactory. Either the coating was not sufficiently thick to prevent the maggots from passing through it, or they went beneath it. In any case, the infestation in the rows treated with this material was as great as in the check rows.

The cost of the material was not great, nor was the time necessary to prepare it. Application, however, had to be carefully made, and the total cost per acre for a single treatment would be about $23 or $24. At least three applications would be necessary following cultivation, which would make this treatment too expensive.

Kerosene Emulsion. — This material was prepared according to the usual formula, and was diluted to three different degrees: 1 part of stock emulsion to 9, 1 to 14 and 1 to 19 parts of water. It was applied in the same way as the soap wash and repeated at intervals of from ten to fourteen days. No injury to the plants at either strength was observed, nor did the different degrees of dilution appear to affect the results as regards the maggots.

Little protection from maggots was found as the result of this treatment. The material for 1 acre would cost about $10, and the cost of labor, making and applying it would be about $12 or $14 more. The total cost for three applications to an acre of onions would therefore be $60 or more, and would make this treatment too expensive, even if it were effective.

Carbolic Acid Emulsion. — This was prepared as follows: soap 1 pound, water 1 gallon, crude carbolic acid 1 pint; dissolve the soap in water (boiling, to hasten solution); add the carbolic acid and churn as for kerosene emulsion until a creamy substance thoroughly emulsified has been produced.

This was diluted to three strengths: 1 part to 30, 1 to 40 and 1 to 50 parts of water. It was applied in the same way as the soap wash and the application repeated every other week.

The results obtained so far as control of maggots is concerned were the most satisfactory of any, decidedly checking the infestation in the rows to which it was applied. On small areas it would appear to be the most effective of the materials tested, and its application to large fields would be determined largely by its cost. This, for materials and labor together, was calculated at from $8 to $12 per acre, according to the strength used. It would probably need to be applied at least three, and probably four times, however, to be effective, which would make the total cost from $35 to $50. It should also be borne in mind that it was not an entire success, but only relatively so. So far as could be determined the three strengths were about equally effective.

General Conclusions.

None of the materials tested proved satisfactory, though the carbolic acid emulsion gave the best results. It was also one of the less expensive treatments, costing from about $8 to $12 per acre for each application. It is not improbable that some of the other materials, applied frequently and with care, might prove of some value, but only on small areas would this be possible at a reasonable expense.

The whole experiment indicates: (*a*) that no entirely effective method of controlling the onion maggot has as yet been discovered; (*b*) that many of those thus far recommended are of little value, at least on large fields; (*c*) that the cost of treatment with most of them is so great as to render them unavailable for large areas. Finally, the most promising line of investigation seems to be the discovery of something which will effectually repel the insects or destroy the maggots, and which can be applied either as a part of the planting process or in connection with cultivation, thus avoiding the necessity of special treatments by combining these with usual methods of cultivation. Experiments along these lines are now being planned.

DEPARTMENT OF HORTICULTURE.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

The experimental work in horticulture has been carried forward during the past year without change of policy or personnel, unless we note the fact that Dr. J. K. Shaw is directing a larger part of his time to the study of pomological problems, and a diminishing part to investigations in plant breeding. Special mention may be made of the beginning of an extended investigation in the interrelations of scion and stock in graftage. It is contemplated that these experiments will cover a period of twenty years or more. They will be conducted in part on land in Amherst leased by the experiment station for this purpose; but certain practical phases of the work will be checked by duplicate tests made in different parts of the State in co-operation with fruit growers. These problems are of great theoretical interest and greater practical importance, and the present studies are begun in the hope of many valuable results to follow.

Attention should be drawn at this time to the increasing demand for practical experiments in floriculture and market gardening. These important industries have been measurably neglected in the experimental work of the past, and the men now engaged in these lines of work have repeatedly signified their wish for help and their willingness to co-operate with the experiment station in planning and carrying out desirable lines of experiment. Projects for experimental work have already been submitted by the heads of the departments of floriculture and market gardening, and the careful consideration of those projects is herewith urged.

Another line of work which should be taken up at the earliest possible date is that of horticultural manufactures, or the home industries of canning, preserving, drying, evaporating, jam and jelly making, etc. These could be made a source of substantial profit to fruit and vegetable growers. While this work should be promoted in all its aspects by the college, it seems that the most important part of it, and the part which should be first taken up, is the work of investigation and practical experiment. A project for the work in horticultural manufactures has been filed, and I also urge careful attention to this matter.

The experimental work in this division, and especially the work now in charge of Dr. J. K. Shaw, demands some additional clerical assistance, both in the field plots and in the office. The present needs could be most efficiently met by the appointment of a graduate assistant who would give one-half his time to this work, the remainder being spent in postgraduate study; and I recommend that such an appointment be made at the earliest possible moment.

THE INHERITANCE OF BLOSSOM COLOR IN BEANS.

J. K. SHAW.

For several years we have given considerable time to the study of heredity in beans. Nineteen varieties have been used, and the method uniformly followed has been to make a cross of two differing types and self-fertilize the progeny through four generations, keeping careful records of the characters under observation as they appeared.

The self-fertilization has been done by covering the plants with muslin bags, each supported by a short stick or bent wire. Some have been grown in the greenhouse during the winter, and these have of course required no protection. Some of the crossing has been done in the greenhouse and some in the field, in which case paper bags have been used for protection from insect interference. The parent plants have each received a number, and our records show just what plants were involved in any particular cross. The system of records used has already been described by the writer.[1] In this way a vast amount of data has been accumulated and many interesting questions are presented for study. It is the purpose of this paper to deal with the inheritance of blossom color, leaving the other characters studied for later consideration.

In the early part of the work the plants used were from commercial seed bought in the open market. When the writer took charge of the work the policy was adopted of securing pure races as quickly as possible by self-fertilizing individual plants, and since then these have been used in the crossing work. It is probable that some of the plants used first, while externally typical of the variety, were not gametically pure and led to confusing results.

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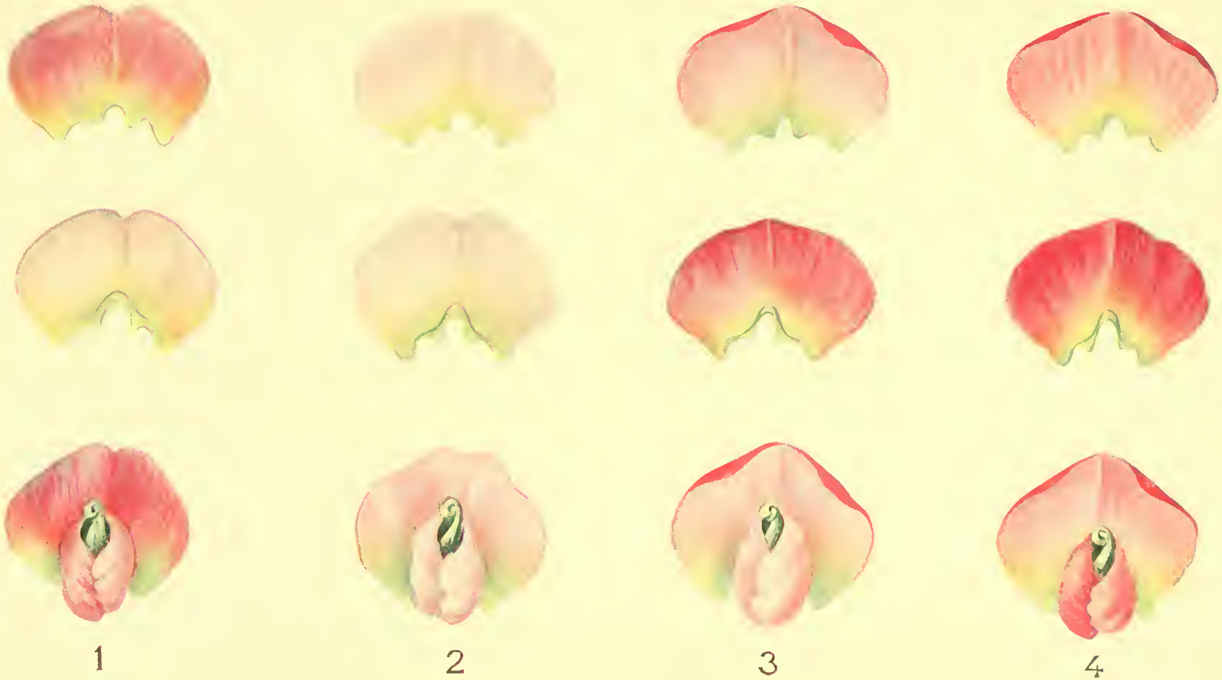
[1] American Naturalist, Vol. XLV., p. 701 (1911).



Flower Colors of Beans.

Fig. 1. Pink. Fig. 2. Light pink. Fig. 3. "Waxy pink." Fig. 4. Crimson. The upper figure in each case represents the inside and the middle figure the outside of the banner petal.

As indicated by external appearance the blossom colors of the varieties under experiment fall under four types. These have been designated as white, light pink, pink and crimson. In addition to these parental colors a new form has appeared, and this has been called "waxy pink" for want of a better term. All the colored types are somewhat variable, and some difficulty has been occasionally experienced, especially in the early stages of the work, in separating them; but it is believed that this has not been serious enough to affect the results. The blossom color of the varieties used is as follows: —

White: —
Creaseback.[1]
Davis Wax.
Golden-eyed Wax.
Keeney Rustless.
Red Valentine.
Wardwell.
White Marrow.
Light pink: —
Burpee Stringless.
Golden Carmine.
Giant Stringless.
Mohawk.
Warren.
Warwick.
Pink: —
Challenge Black Wax.
Currie.
German Black Wax.
Prolific Black Wax.
Crimson: —
Blue Pod Butter.

Inasmuch as the blossom color and the pigmentation of the seed-coat seem to be correlated, it may be well to state here the seed-coat colors of these varieties, as follows: —

Blue Pod Butter, buff.
Burpee Stringless, coffee brown.
Challenge Black Wax, black.
Creaseback, white.
Currie, black.
Davis Wax, white.
German Black Wax, black.
Giant Stringless, yellow.
Golden Carmine, mottled, buff and reddish.
Golden-eyed Wax, white; small yellow eye.
Keeney rustless, white; large dark-reddish mottled eye.
Mohawk, mottled, reddish brown.
Prolific Black Wax, black.

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[1] In nomenclature we follow Jarvis, Cornell Exp. Sta. Bull. No. 260. Any one desiring a complete description of these varieties is referred to this bulletin or Bu. Plant Ind. Bull. No. 109.

Red Valentine, reddish mottled.
Wardwell, white; large dark-brownish eye.
Warren, deep red.
Warwick, deep reddish mottled.
White Marrow, white.

The blossoms of the varieties classified as white-flowered have been invariably a pure white so far as observed, with the exception of Red Valentine. This sort has occasionally shown flowers with a very slight pinkish tinge on the more exposed positions of the keel; while drying with age they take on a distinct waxy tinge. It should be noted that the seeds of this variety have mottled seed-coats while all the other white-flowered varieties are either white seeded or eyed.

The varieties classified as light pink have flowers with a distinct tinge of pink, especially on the keel. They do not show the waxy color of white-flowered sorts while drying, and are readily separated from them even though this pink tinge may be very slight. From the pink-flowered sorts, on the other hand, they are not so easily distinguished, and it is evident that a few errors have here been recorded, but care has been taken not to allow these to lead to any false conclusions.

The pink-flowered varieties have a deep shade of pink over the entire flower, including the inside of the banner petal, but the outside is white. The so-called crimson flowers of the Blue Pod Butter are more properly a purplish crimson, and invariably the leaves and stems of the plants are deeply tinged with dark purple. These flowers are distinguished from the pink ones, not only by their darker shade but more certainly by the outside of the banner petal which is purplish crimson instead of uncolored.

The waxy pink flowers have appeared only in crosses having Blue Pod Butter as one of their parents. They resemble the light pink blossoms but are readily distinguished from them. The pigment seems deepest on the outside of the banner, and the whole plant invariably has a peculiar waxy-brownish-yellow appearance.

These colors are well represented in the colored plate.

Turning now to a discussion of the tabulated data, Table 1 shows the results of crossing varieties with light pink flowers with white-flowered sorts, where only light pink and white-flowered plants resulted. Some such crosses gave pink-flowered plants, and these are given in Table 2. The results shown are generally in accordance with Mendelian expectation, assuming the light pink blossom to be dominant over white. There are two cases where a white-flowered parent has colored offspring. It is possible that in the cross Red Valentine and Giant Stringless this is due to error in observation of the color of the flowers of the parent plant on account of the effect of bagging to insure self-fertilization, this having a tendency in some cases to check color development. The same may be said regarding the similar case in Red Valentine × Mohawk. The case of the single light pink plant in Golden-eyed Wax × Giant Stringless is unexplained. Some departures from the numerical expectation are recorded. A marked excess of white-flowered plants occurs in the crosses involving Golden-eyed Wax, and a similar excess is shown in later tables when this variety is involved.

Table 1. — *Light Pink and White.*

	F_1.	F_2.			F_3 and F_4.					
					White parents.			Light pink parents.		
		White.	Light Pink.	Total.	White.	Light Pink.	Total.	White.	Light Pink.	Total.
Burpee Stringless × Red Valentine,	Light pink,	8	40	48	-	-	-	0 32	8 67	8 99
Red Valentine × Burpee Stringless,	Light pink,	22	71	93	25	0	25	0 47	107 90	107 137
Burpee Stringless × Wardwell,	Light pink,	9	19	28	6	0	6	3	14	17
Burpee Stringless × White Marrow,	Light pink,	17	67	84	58	0	58	0 96	54 246	54 342
White Marrow × Burpee Stringless,	Light pink,	15	47	62	41	0	41	0 59	205 194	205 253
Giant Stringless × Golden-eyed Wax,	Light pink,	61	88	149	10	0	10	-	-	-
Golden-eyed Wax × Giant Stringless,	Light pink,	26	34	60	16	1	17	0 10	17 21	17 31
Giant Stringless × Red Valentine,	Light pink,	5	34	39	18	0	18	0 2	31 3	31 5
Red Valentine × Giant Stringless,	Light pink,	16	25	41	17 33	18 0	35 33	-	-	-
Giant Stringless × Wardwell,	Light pink,	24	53	77	84	0	84	0 25	14 88	14 113
Mohawk × Red Valentine,	Light pink,	9	22	31	-	-	-	-	-	-
Red Valentine × Mohawk,	Light pink,	17	27	44	89 6 0	0 6 23	89 12 23	0 20	15 51	15 71

In Table 2 are given results from certain crosses that are not in accordance with expectation, in that deeper colored flowers appear among the offspring than those possessed by either parent variety. In the cross of Golden-eyed Wax × Burpee Stringless there appear two pink and one crimson flower in the F_3 generation. These all occur among the progeny of a single selfed plant having light pink flowers. The pink-flowered plants bore black beans, while the crimson-flowered plant bore dark mottled beans. The significance of this correlation will be discussed a little later. In the crosses of Burpee Stringless and Giant Stringless with Keeney Rustless, pink flowers occur in both the F_2 and later generations, and in such numbers as to preclude the possibility of errors in observation. Coincident with these pink flowers occur black or dark mottled seeds, and coincident with the white flowers appear eyed beans, a character coming from the eyed parent, Keeney Rustless. The cross of White Marrow × Golden Carmine presents a variety of surprises hard to comprehend. As will be shown later, this is common with the White Marrow. It is most undependable in its behavior in crosses. It is evident that some of this is due to a mixture of strains which may be alike in external appearance but behave differently in crossing, but there are other abnormalities shown that will bear much investigation. The reciprocal crosses of Warwick and Creaseback show pink flowers, again coincident with black pigment in the seed coat. It is evident that Creaseback carries a factor that blackens any pigment it may encounter, at least so far as our experience goes, and this blackening is accompanied by pink flowers. None of the pink-flowered plants have bred true to flower color. All seem to be heterozygous.

TABLE 2. — *Light Pink and White.*

	F_1	F_2.				F_3 and F_4.								
						WHITE PARENT.	LIGHT PINK PARENTS.				PINK PARENTS.			
		White.	Light Pink.	Pink.	Total.	White.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.
Golden-eyed Wax × Burpee Stringless, .	Light pink, .	9	25	0	32	31	0	21	0	21	-	-	-	-
							19	63	0	82				
							16	64	2	83[1]				
Keeney Rustless × Burpee Stringless, .	Light pink, .	3	8	6	17	4	2	0	22	24	6	8	13	27
							4	11	0	15				
Giant Stringless × Keeney Rustless, .	Light pink, .	5	5	10	20	-	3	4	11	18	6	0	27	33
							1	8	0	9	1	15	0	16
White Marrow × Golden Carmine, . .	-	6	2	7	15	42	0	15	0	15	1	0	5	6
							0	12	0	13[1]	0	18	45	64[1]
							0	1	0	6[2]	0	0	6	12[3]
							0	6	1	7	0	2	0	2
Warwick × Creaseback, ...	Pink, . .	9	13	66	88	-	-	-	-	-	-	-	-	-
Creaseback × Warwick, ...	Pink, . .	4	3	15	22	59	0	76	0	76	-	-	-	-
							40	120	0	160				

[1] Also 1 crimson, see text.

[2] Also 5 "waxy pink."

[3] Also 6 crimson.

In Tables 3 and 4 are given our results of crossing pink with white-flowered varieties, the division into two tables being simply for convenience in arrangement. A striking thing shown in this table is the excess of white-flowered plants in the crosses involving Golden-eyed Wax. This occurs in all cases except in the F_2 generation of the cross with Prolific Black Wax. It is seen also in crosses with light pink-flowered sorts, especially with Giant Stringless in Table 1, also in crosses with Blue Pod Butter in Table 5. The total number of hybrid plants from crosses of Golden-eyed Wax with pigmented flowered variations is 1,053, of which 407 are white-flowered, while the expectation of one-fourth of the total number is 262. This is a proportion of 1.59:1 instead of 3:1. This departure from expectation is probably due to a correlation between blossom color and seed-coat colors or color patterns. Another thing that calls for explanation is the occurrence of light pink flowers in the second generations in Table 4. These appear in a majority of the crosses but not in all of them. There can be little reason to doubt that nearly all, at least, of these classifications of blossom color are correct, for our policy has been not to record a departure from expectation in any case of doubt, but only where the unexpected character is reasonably typical. As previously explained, these two color types are quite distinct. It may be observed that White Marrow gives peculiar results here as in crosses already discussed. It is probable that the appearance of the light pink blossoms in these crosses is connected with the pigmentation of the seed-coat, and may be explained by a study of the seed-coat color. White Marrow evidently carries several factors modifying pigmentation both of seed-coat and blossom.

TABLE 3. — *Pink and White.*

	F₁.	F₂.				F₃ AND F₄.				
						WHITE PARENTS.		PINK PARENTS.		
		White.	Light Pink.	Pink.	Total.	White.	Pink.	White.	Pink.	Total.
Challenge Black Wax × Davis Wax,	Pink,	84	5	245	334	-	-	0 8	11 19	11 27
Challenge Black Wax × Golden-eyed Wax,	Pink,	73	14	107	194	69	0	0 9	56 16	56 25
Challenge Black Wax × Creaseback,	Pink,	82	4	367	453	-	-	0 9	19 33	19 42
Golden-eyed Wax × Currie,	Pink,	99	10	140	249	55	0	0 39	34 33	34 79[1]
Currie × Red Valentine,	Pink,	43	26	71	140	65	0	0 13	114 11	114 24
Red Valentine × Currie,	-	103	7	292	402	185	0	0 33	143 100	143 133
Currie × White Marrow,	-	38	0	67	105	225	0	0 48	30 135	30 231[2]
Golden-eyed Wax × Prolific Black Wax,	-	19	0	28	47	94	0	0 10	4 21	4 31
Creaseback × Prolific Black Wax,	Pink,	15	0	25	40	-	-	-	-	-

[1] Also 6 light pink and 1 crimson.

[2] Also 8 light pink.

TABLE 4. — *Pink and White.*

	F₁.	F₂.				F₃ AND F₄.											
						WHITE PARENTS.				LIGHT PINK PARENTS.				PINK PARENTS.			
		White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.
White Marrow × German Black Wax,	Pink, .	27	27	44	98	31	0	0	31	4	13	0	17	0	7	5	12
										0	2	9	11	9	11	10	30
Prolific Black Wax × Red Valentine,	–	13	12	21	46	54	13	0	67	23	1	0	24	0	0	34	34
						2	0	5	7	14	0	10	24	17	0	55	72
						158	0	0	158	5	2	6	13	25	7	45	77
Red Valentine × Prolific Black Wax,	Pink, .	60	170	42	272	128	0	0	128	2	0	3	5	0	0	42	42
		9	0	18	27					0	3	6	9	7	0	25	32
										0	0	28	28	0	1	5	6
														11	8	34	53
White Marrow × Prolific Black Wax,		2	0	10	12	60	0	0	60	1	1	1	3	24	0	82	106

In Table 5 are shown the results of crossing various white-flowered varieties with Blue Pod Butter, the one crimson-flowered variety under observation. The results of these crosses present several unexpected complications. The most striking is the new and distinct blossom color designated as "waxy pink." This resembles the light pink more than any of the other colors, the amount of coloration being about the same, but its distribution is different, being heaviest on the outer part of the banner petal. It carries no suggestion of purple, and the entire plant has a waxy-yellow tinge distinct from the deeper green of the other plants. It will be noted that this type appears in all crosses of Blue Pod Butter, given in Table 5, except those with Davis Wax and Creaseback. It also appears in all crosses of Blue Pod Butter with varieties having light pink flowers shown in Table 7, but appears in none of the crosses with pink-flowered black-seeded varieties given in Table 8. It must be regarded as resulting from a cross of Blue Pod Butter with some, but not all, white or light pink-flowered varieties.

TABLE 5. — *Crimson and White.*

	F₁.	F₂.						F₃ and F₄.											
								White Parents.						Light Pink Parents.					
		White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.
Blue Pod Butter × Davis Wax, .	Crimson, .	7	0	9	11	0	27	–	–	–	–	–	–	–	–	–	–	–	–
Davis Wax × Blue Pod Butter, .	Crimson, .	17	0	11	41	0	69	–	–	–	–	–	–	–	–	–	–	–	–
Blue Pod Butter × Golden-eyed Wax,	4 crimson, 1 pink.	17	3	7	21	7	55	–	–	–	–	–	–	–	–	–	–	–	–
Golden-eyed Wax × Blue Pod Butter,	Crimson, .	24	0	5	23	8	60	5 6	0 0	0 0	0 1	0 1	5 8	–	–	–	–	–	–
Blue Pod Butter × Red Valentine, .	Pink, .	8	3	5	31	2	49	–	–	–	–	–	–	–	–	–	–	–	–
Blue Pod Butter × Wardwell, . .	Pink, . .	12	3	6	16	3	40	5	0	1	0	0	6	3	4	0	0	4	11
Wardwell × Blue Pod Butter, . .	Pink, . .	14	7	11	18	5	55	8	0	0	0	0	8	–	–	–	–	–	–
Blue Pod Butter × Creaseback, .	Crimson, .	74	2	28	137	0	241	–	–	–	–	–	–	–	–	–	–	–	–
Creaseback × Blue Pod Butter, .	Crimson, .	37	1	9	77	0	124	–	–	–	–	–	–	–	–	–	–	–	–
Blue Pod Butter × White Marrow, .	30 crimson, 5 pink.	26 13 14	0 14 6	1 17 7	27 35 25	4 6 7	58 81 59	254 12 31	0 0 2	0 10 0	0 0 0	0 0 26	254 22 59	3 0 0	0 0 2	10 8 1	0 0 1	0 0 5	13 8 9
White Marrow × Blue Pod Butter, .	Crimson, .	3 12	4 4	6 5	4 23	0 7	17 51	5	0	0	0	0	5	3	1	0	0	0	4

TABLE 5. — *Crimson and White* — Concluded.

	F₃ AND F₄ — *Con.*																	
	PINK PARENTS.						CRIMSON PARENTS.						WAXY PINK PARENTS.					
	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.
Blue Pod Butter × Davis Wax,	0	0	17	0	0	17	0	0	0	5	0	5	-	-	-	-	-	-
	3	0	16	0	0	19	3	0	1	2	0	6						
Davis Wax × Blue Pod Butter,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blue Pod Butter × Golden-eyed Wax,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Golden-eyed Wax × Blue Pod Butter,	2	1	6	1	0	10	0	0	0	6	0	6	4	0	0	0	7	11
	5	0	14	0	0	19	4	0	1	3	0	8						
							5	0	2	3	1	11						
Blue Pod Butter × Red Valentine,	-	-	-	-	-	-	0	1	1	8	1	11	-	-	-	-	-	-
Blue Pod Butter × Wardwell,	-	-	-	-	-	-	0	0	6	11	0	17	-	-	-	-	-	-
							0	0	4	4	2	10						
							0	1	1	11	3	16						
Wardwell × Blue Pod Butter,	3	1	8	0	0	12	4	0	2	4	0	10	0	3	0	0	3	6
							5	1	7	14	1	28						
Blue Pod Butter × Creaseback,	0	0	10	0	0	10	0	0	4	13	0	17	-	-	-	-	-	-
	6	1	27	0	0	34	6	0	0	44	0	50						
	3	0	7	2	0	12	23	0	12	59	0	91						
Creaseback × Blue Pod Butter,	-	-	-	-	-	-	7	0	0	23	0	30	-	-	-	-	-	-
							2	0	4	5	0	11						
Blue Pod Butter × White Marrow,	0	0	10	0	0	10	0	0	0	8	0	8	7	0	0	0	15	22
	0	0	2	0	21	23	0	0	3	17	0	20	2	0	0	1	1	4
	2	1	6	0	0	9	0	3	4	5	0	12						
	49	0	117	0	0	166	4	0	0	13	0	17						
							12	0	9	30	0	51						
							0	0	0	8	2	10						
							0	0	4	4	1	9						
							7	0	0	6	2	15						
							4	1	5	12	0	22						
White Marrow × Blue Pod Butter,	0	2	5	0	0	7	0	0	0	3	4	7	0	1	0	0	4	5

In the third and fourth generations from the cross it appears commonly among the progeny of light pink and crimson parents, and in two cases from white-flowered parent plants, and in one case from a pink-flowered parent. It is probable that these three cases should be regarded as exceptional, and it is possible that one or two may arise from erroneous observations. When self-fertilized it commonly breeds true, or it may yield light pink or white progeny. In one case it yields one crimson-flowered plant. There have been several cases where such plants have appeared most unexpectedly from parent plants of lighter-colored flowers, a thing that we are unable to explain unless they be regarded as mutants.

Light pink flowers appear in all crosses of Table 5, except the one with Davis, and pink flowers in all of them.

A study of the ratios of these several blossom colors leads only to confusion. It is probable that the theoretical ratios differ in the different crosses, and, as in many other cases, are correlated with the seed-coat pigmentation.

Table 6 gives the results of crossing pink and light pink-flowered varieties. Only the parent types appear, as a rule; the pink is uniformly dominant, and the proportions, while departing considerably in some cases from the expected ratio of 3:1, are perhaps not further than might be expected.

TABLE 6. — *Pink and Light Pink.*

	F1.	F2.			F3 AND F4.					
					LIGHT PINK PARENTS.			PINK PARENTS.		
		Light Pink.	Pink.	Total.	Light Pink.	Pink.	Total.	Light Pink.	Pink.	Total.
Burpee Stringless × German Black Wax,	Pink,	17	79	96	131	0	131	0	104	104
					2	2	4	19	61	80
German Black Wax × Burpee Stringless,	Pink,	25	48	73	20	0	20	0	111	111
					36	68	104	37	56	93
Burpee Stringless × Prolific Black Wax,	Pink,	16	8	24	8	0	8	0	6	6
					2	1	3	2	11	13
Warwick × Challenge Black Wax,	Pink,	10	6	16	257	0	257	0	100	100
								7	34	41
Challenge Black Wax × Warwick,	Pink,	9	20	29	-	-	-	-	-	-
Currie × Mohawk,	Pink,	97	202	300[1]	199	0	199[2]	0	56	56
								8	19	27
Mohawk × Currie,	Pink,	16	22	38	-	-	-	-	-	-
Prolific Black Wax × Mohawk,	-	0	3	3	-	-	-	14	45	59

[1] Also 1 white flower.

[2] One light pink parent gave 21 white, see text.

There are, however, a few irregularities. One is the appearance in F_3 and F_4 of pink-flowered plants from light pink parents, and another is the appearance of white-flowered plants in the cross of Currie × Mohawk. The single white-flowered plant in F_2 was covered with a muslin bag for self-fertilizing which may have suppressed the color, but the 21 whites from a light pink parent cannot be thus accounted for; they bred true in the succeeding generations so far as flower color was concerned.

TABLE 7. — *Crimson and Light Pink.*

	F1.	F2.					F3 AND F4.																	
							LIGHT PINK PARENTS.					PINK PARENTS.					CRIMSON PARENTS.					WAXY PINK PARENTS.		
		Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	Light Pink.	Waxy Pink.	Total.
Blue Pod Butter × Burpee Stringless,	Crimson,	33 16	23 34	78 64	3 1	137 115	120 0 71	0 0 0	0 0 0	0 41 55	120 41 127[1]	0 15	7 28	0 0	0 0	7 43	0 0 0 1 0 3	0 19 8 0 0 4	139 33 43 16 11 9	0 0 1 4 1 1	139 52 52 21 12 17	0	44	44
Burpee Stringless × Blue Pod Butter,	Crimson,	17 6	21 20	60 46	0 5	101 77	2 32	0 0	0 0	0 12	2 44	0 9	27 36	0 0	0 0	27 45	0	0	18	0	18	-	-	-
Blue Pod Butter × Giant Stringless,	Crimson,	6	2	8	1	17	5	0	0	6	11	2	17	0	0	19	1	2	9	0	12	-	-	-
Giant Stringless × Blue Pod Butter,	Crimson,	8	15	35	11	69	-	-	-	-	-	2	0	0	0	2	0	1	7	0	8	-	-	-
Blue Pod Butter × Mohawk,	Crimson,	3	1	3	2	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mohawk × Blue Pod Butter,	Crimson,	1	3	9	1	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blue Pod Butter × Warwick,	Crimson,	7	12	23	9	51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warwick × Blue Pod Butter,	Crimson,	28	33	87	21	169	32	0	0	0	32	0 25	5 30	0 0	0 0	5 55	0 1	0 1	30 2	14 2	44 6	0 3	51 16	51 19
Low Champion × Blue Pod Butter,	Crimson,	7	11	38	6	62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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[1] Also 1 white.

The crosses of Blue Pod Butter, the crimson-flowered varieties given in Table 7, have been already discussed in connection with Table 5. Only one white-flowered plant appeared among those crosses, and that was in the F_3 generation of Blue Pod Butter × Burpee Stringless. No reason for its appearance can be assigned.

Table 8 gives the results of crossing Blue Pod Butter with pink-flowered black-seeded sorts. As already stated none of the waxy-pink flowers appear among these crosses. White flowers appear among the progeny of the crosses of Blue Pod Butter × German Black Wax, but not in the reciprocal cross, also in the cross of Currie and Blue Pod Butter. Light pink flowers appear rarely, and they may be extreme variants of pink flowers in which the color has been partially suppressed by environmental conditions.

TABLE 8. — *Crimson and Pink.*

	F_1.	F_2.					F_3 AND F_4.									
							PINK PARENTS.					CRIMSON PARENTS.				
		White.	Light Pink.	Pink.	Crimson.	Total.	White.	Light Pink.	Pink.	Crimson.	Total.	White.	Light Pink.	Pink.	Crimson.	Total.
Blue Pod Butter × Challenge Black Wax,	Crimson,	0	2	20	56	78	-	-	-	-	-	-	-	-	-	-
Challenge Black Wax × Blue Pod Butter,	Crimson,	0	0	67	170	237	0 0	0 1	59 1	0 7	59 9	0 0 0	0 0 1	0 4 3	17 15 15	17 19 19
Blue Pod Butter × Currie,	Crimson,	0	0	8	48	56	-	-	-	-	-	-	-	-	-	-
Currie × Blue Pod Butter,	Crimson,	0	4	89	156	249	0 2 5	0 0 4	35 3 18	0 0 0	35 5 27	0 0 2	0 0 9	0 7 3	14 43 9	14 50 23
Blue Pod Butter × German Black Wax,	Crimson,	10 0	0 0	12 9	31 25	53 34	0 7	0 0	10 20	0 0	10 27	0 6 2	0 0 1	0 4 2	13 13 9	13 23 14
German Black Wax × Blue Pod Butter,	Crimson,	0	0	17	59	76	0 0 0	0 1 0	6 19 6	0 0 22	6 20 28	0	0	14	25	39
Blue Pod Butter × Prolific Black Wax,	Crimson,	0	0	56	141	197	0	0	108	0	108	0 0	0 0	0 10	38 10	38 20
Prolific Black Wax × Blue Pod Butter,	Crimson,	0	0	32	112	144	0	0	27	0	27	0	0	0	25	25

It is the usual expectation that when two white-flowered varieties are crossed only white flowers should result. Table 9 shows that in beans this is by no means true. It comprises all such crosses save one, Wardwell × Golden-eyed Wax, which has been bred for three generations from the cross, yielding about 100 plants, with none but white flowers appearing. All the rest of such crosses have yielded colored flowers in each generation bred. All these crosses involve varieties one or both of which bear pigmented seeds, these adding further evidence that blossom color is governed largely by the pigmentation of the seed coat.

TABLE 9. — *White and White.*

	F₁.	F₂.				F₃ and F₄.											
						WHITE PARENTS.				LIGHT PINK PARENTS.				PINK PARENTS.			
		White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.
Red Valentine × Golden-eyed Wax,	–	16 175 8	16 0 28	0 0 2	32 175 38	169 1	0 3	0 10	169 14	0 0 3 3	4 0 12 0	0 6 0 8	4 6 15 11	0 1 4	0 1 0	38 14 21	38 16 25
Golden-eyed Wax × Red Valentine,	White,	61	5	0	66	–	–	–	–	–	–	–	–	–	–	–	–
Red Valentine × Keeney Rustless,	Pink,	6 12	11 0	0 24	17 36	33	0	0	33	16	0	23	39	0 10	0 0	5 33	5 43
Red Valentine × White Marrow,	2 light pink, 2 pink.	47 19 28	0 36 29	0 0 1	47 55 58	165 20	0 16	0 0	165 36	0 10	33 13	0 0	33 23	–	–	–	–
White Marrow × Red Valentine,	–	6	11	0	17	65	0	0	65	7	0	12	19	0	0	57	57
Golden-eyed Wax × Creaseback,	–	15	0	13	28	5	0	0	5	–	–	–	–	69	0	65	134
Golden-eyed Wax × White Marrow,	–	40 34	56 2	0 0	96 36	9	0	0	9	10	38	0	48	–	–	–	–
White Marrow × Golden-eyed Wax,	–	12	11	0	23	15 41	0 22	0 0	15 63	–	–	–	–	–	–	–	–
Wardwell × Keeney Rustless,	Light pink,	16	0	0	16	88 10	0 0	0 3	88 13	–	–	–	–	–	–	–	–
White Marrow × Keeney Rustless,	–	15	8	0	23	30	0	0	30	26	17	0	43	–	–	–	–
Wardwell × White Marrow,	Light pink,	12 13	9 1	0 16	21 30	38	0	0	38	–	–	–	–	12	3	16	31
Davis Wax × Keeney Rustless,	Pink,	6	0	15	21	–	–	–	–	–	–	–	–	–	–	–	–

The following crosses of two light pink flowered varieties gave only light pink flowered plants in the progeny.

Golden Carmine × Mohawk.
Mohawk × Golden Carmine.
Burpee Stringless × Giant Stringless.
Mohawk × Burpee Stringless.
Giant Stringless × Mohawk.
Mohawk × Giant Stringless.

One cross of Warren × Burpee Stringless gave, in F_2, 6 light pink, 3 pink, 13 crimson and 2 waxy pink, the F_1 plants being light pink. It should be said that while both of these varieties are classed as light pink they are not identical in the appearance of the blossom color. Only one cross of pink-flowered varieties has been made, — Challenge Black Wax × Prolific Black Wax. All the resulting plants have borne only pink flowers.

In this paper we have attempted little more than setting forth some of the facts concerning the inheritance of blossom color that have appeared in the work of the past five years. Beyond doubt the interpretation of these results is to be made through an analysis of the records of the inheritance of seed-coat color. It is hoped that this work may be accomplished, including another season's observation, in time for presentation in the next annual report of the experiment station.

DEPARTMENT OF VETERINARY SCIENCE.

REPORT OF THE VETERINARIAN.

JAS. B. PAIGE, D.V.S.

During the past year the policies of former years in dealing with the work in this department have been adhered to. The personnel of the department is the same as last year. With the addition of Dr. G. E. Gage to the working force it has seemed possible to devote more time to investigation problems than in former years, when one man had to attend to the entire work of the department of both college and experiment station. Owing to the demands of a larger number of students in some of the classes, and an increase in the amount of instruction given, it has been found that much of the time of an additional assistant has been utilized, not for investigational work as had been expected, but for teaching.

If the veterinary department of the experiment station is to render such service to the stock owners of the State as they are justly entitled to, it is imperative that a competent pathologist, who shall devote practically all his time to investigational problems, be added to the staff of the department at the earliest possible date.

There are numerous important problems that call for immediate and thorough study. Some of these studies promise the most flattering results from a practical and economic standpoint in the prevention, cure or eradication of animal diseases.

During the year there has been the usual amount of correspondence with farmers from all parts of the State relative to the existence and treatment of disease of farm animals. This correspondence is fruitful of the best results in many instances. It is often possible, from the information received from a stock owner by letter, to diagnose the disease of his animal and to advise a line of treatment that will lead to a cure of it. At other times, additional information may be requested or a specimen asked for, which, received and examined, enables us to arrive at a correct diagnosis upon which a successful course of treatment for the individual animal or for an entire herd is based.

The diagnosis work that is carried on each year is gradually increasing. It is closely correlated with the correspondence mentioned above. Frequently specimens are sent by farmers direct to the department, with a request that an examination be made, and a report as to the nature of the disease, its cause, prevention or cure returned. At times material from sick or dead animals is sent upon request of the department when a positive diagnosis cannot be made from information obtained by letter from the owner of the animal. Since Jan. 1, 1912, approximately 100 specimens have been received, examined and information returned to the senders of them with advice as to course of treatment to be followed in dealing with the several diseases. This diagnosis work is not only beneficial to the farmers, enabling them in many instances to avail themselves of the services of the station veterinarian, but it is of value to the department, as it provides a means by which we are kept in touch with the various ailments of farm animals throughout the State. In addition, the material received from different sections of the State furnishes, at times, valuable material for demonstrations with the students taking the courses in veterinary science and pathology.

It frequently happens that valuable material for study is received from stock owners. Through specimens that have been received we have on several occasions been able to diagnose the existence of animal diseases in Massachusetts that were not supposed to exist here, and also we have found disease not previously described. As good examples of these may be mentioned verminous bronchitis of sheep and a peculiar paralytic disease of fowls.

Among some of the more interesting specimens that have come to the department during the year may be mentioned verminous bronchitis of sheep; necrotic stomatitis of calf; traumatic pericarditis of steer; purulent endometritis and uterine torsion of cow; cholera and demodectic scabies of the pig; traumatic peritonitis, due to perforation of gizzard of fowl with wire nail; variola; fatty infiltration of liver of fowl; and bacillary white diarrhœa of chicks. Several samples of milk, contaminated with special species of bacteria causing such abnormal conditions as "curdled," "bitter" and "gassy" milk, have been received and examined, and advice given as to how the trouble could best be eliminated and prevented.

Whenever the seriousness and nature of an outbreak of disease seems to warrant it a visit is made to the farm where the trouble makes its appearance, for the purpose of making a critical study of conditions under which the disease of the animals has developed and exists. In such cases, in order not to encroach upon the field and practice of the local veterinarian, provided there is one in the locality, the visit is usually made in company with the local practitioner.

Another field in which the department has been able to render some service to the stockmen of the State has been in the examination of stables and advising with reference to the improvement of sanitary conditions. This has not only been done with stables already constructed, but also, in some instances, plans of proposed stables have been submitted for examination and suggestions.

As already mentioned, the department has not been able to carry on as much original investigation as it desired on account of the amount of teaching that it has been necessary to do. This has been due, in part, to the fact that we have taught throughout the year the courses in bacteriology that eventually will be taken over into the new department of microbiology, created by trustee vote last year, and to which Dr. C. E. Marshall was elected the head. When we are relieved of this line of teaching it is hoped that more time can be given to investigation problems. It will not, however, completely remedy the difficulty, as courses in pathology will be introduced into the curriculum that will be carried by this department. While these will not be as time-consuming as the work in bacteriology, they will interfere sufficiently with the class of investigational work that is demanded to warrant the employment of a pathologist on the experiment station staff who shall be able to devote practically his entire time to the study of pathological problems that are pressing for solution.

As mentioned in the report of last year, there is an unusual amount of hog cholera in the State as compared with former years. It is assuming alarming proportions, more especially in herds fed upon "city" swill or garbage. Its cause in these herds is to be attributed to an infection following the ingestion of uncooked pork scrap, from sources where cholera exists, that finds its way into the swill barrel of the hotel, boarding house or private house, and finally to the trough of the hogs. Once an animal of the herd becomes affected it spreads contagion rapidly to healthy animals with which it is kept.

The department, in co-operation with Mr. Fred F. Walker, Commissioner of the Department of Animal Industry, under whose jurisdiction all contagious animal diseases come, has undertaken some investigations to determine more accurate methods for the diagnosis of cholera in the hog, and its cure and control by the use of anti-hog cholera serum.

In December last, in company with Mr. Walker, I attended the meeting of the State live stock sanitary boards at Chicago, where means and methods for the preparation of serum and the control of the disease were fully discussed by the highest authorities in the country. Since then serum has been used upon several lots of hogs, in which cholera was known to exist, to determine its value as a curative and preventive agent. The herds are located in the middle part of the State so as to permit of occasional inspection without the sacrifice of too much time.

While the work upon hog cholera has not progressed sufficiently to warrant a full report at this time, I feel justified in predicting that by the use of properly prepared serum, under certain conditions, we shall be able to greatly lessen the annual loss to the swine owners from this disease, and in the end succeed in protecting against its ravages to the extent that it may be made one of the most profitable branches of animal industry in the Commonwealth.

Already steps have been taken to prepare, in an experimental way, small quantities of anti-hog cholera serum in the department. If the results of the experiment seem to warrant it, it is possible that in the near future the experiment station may be justified in preparing the serum on a sufficiently large scale to enable it to be distributed at a slight cost, sufficient to pay the actual cost of production, to the hog owners of the State. Should this be done it would be necessary to co-operate with the Department of Animal Industry.

Some years ago, working with the Chief of the Cattle Bureau, of the State Board of Agriculture, the department organized the work for the prevention of black leg in cattle by the use of vaccine, obtained from the Bureau of Animal Industry of the Federal Department of Agriculture. The supervision of the work is still in the veterinary department, in a general way, but no time is given to the actual vaccination of animals about the State, this being done by the special agent of the present Department of Animal Industry.

Although Dr. George E. Gage, assistant professor of animal pathology of the veterinary department, receives no compensation from the experiment station, he has devoted as much time as his teaching duties would permit to the investigation of several important avian diseases, among which is one that appears, from the work already done, never to have been described before. The study of this obscure and interesting disease is being carried along as rapidly as possible under existing conditions, and it is hoped that at a later date the details of the investigation will be brought out in bulletin form.

REPORT OF CRANBERRY SUBSTATION FOR 1912.

H. J. FRANKLIN.

The experiments conducted and observations made during the year may be discussed under the eight following heads: weather observations, frost protection, fungous diseases, varieties, blossom pollination, fertilizers, insects and miscellaneous.

1. Weather Observations.

The season's observations began late in April, the Weather Bureau having at this time installed the following instruments at the station bog: elevated instrument shelter, thermograph, barograph, hygrograph, triple register (for sunshine, wind direction and wind velocity) with battery and wiring, weather vane, anemometer, rain gauge, psychrometer, two maximum and four minimum thermometers and a sunshine recorder.

With these instruments the first really thorough and serious year's work in investigating Cape Cod frost conditions, in their relations to cranberry culture, was carried out. An unusually large number of frosty nights during the first part of the season, especially in June, favored this investigation, and as a result much valuable information was accumulated. It now seems that it may in time be possible to forecast frosts with gratifying accuracy. The Southern Massachusetts Telephone Company has considerably improved its distribution of the frost warnings sent out from Boston by the district forecaster of the Weather Bureau. In addition to these warnings the substation has undertaken to make special early evening forecasts for the benefit of any who may wish to telephone in for them on doubtful nights. It is not expected that the growers will place full reliance on these forecasts at present, but it is hoped that they may be of assistance in case of doubt, and that they may in time become fully reliable. However, there is so much at stake when a bog promises a good crop that it will probably be best for the growers to provide themselves with the necessary instruments and learn to make their own forecasts, because there is such a variety of conditions in different parts of the Cape.

The season's records seem to show that the early evening dew point, which has been shown to be of no value as an indicator of the minimum night temperature in some parts of the country, can be relied upon to a considerable extent in forecasting such temperatures on the Cape. The records further seem to show that the best indications that a frost may be expected on any night during the usual period of frost danger are the following: —

1. Low dew point (50° F. or below at substation shelter).
2. High (above 30) and rising barometer.
3. An all day's wind from a northerly, northeasterly or northwesterly direction, dying out in the early evening.
4. A clear sky.
5. A low maximum day temperature.
6. A low and falling early evening temperature.

The readings of the maximum and minimum thermometers and the amount of precipitation were telegraphed to the office of the United States Weather Bureau at Boston every morning after April 25 during the spring and fall periods of frost danger.

2. Frost Protection.

Because of the failure of a circulating pump, it was impossible to carry out tests with the Skinner system, as had been planned, during the spring frost period. Certain apparent disadvantages connected with the use of this system for frost protection have been discovered. In the first place, the pump and engine required for supplying water under the necessary pressure for a system covering several acres are more expensive than at first supposed. The Skinner Irrigation Company states that it is necessary to sprinkle most crops with water every two minutes during a frosty night in order to afford sufficient protection. It seems possible, however, that the injury caused by frost may be prevented by sprinkling the frosted plants with water at about sunrise, and so drawing the frost out of them gradually before the heat of the sun strikes them. Frost injury appears to be caused not by the freezing but by too rapid withdrawal of the frost. If this is true, it may be possible to sprinkle a cranberry bog with the Skinner system, or some other similar system, a section at a time, and so provide protection for the whole bog with an engine and pump only large enough to pump water for one section. Experiments have been planned to test the practicability of this method.

Another drawback to the Skinner system is the clogging of the nozzles. This gave much trouble in the small system installed at the station bog, and market gardeners who have had long experience with this system meet the same difficulty. Because of this it is now planned to test another system, which has been devised for the same purpose, with rotating nozzles set far apart and large enough to allow small particles in the water to pass through them instead of clogging.

Two extensive tests with 65 3-gallon Hamilton orchard heaters were carried out in the late fall and early winter. These tests showed that it is possible to raise the temperature sufficiently to protect from frost by means of these heaters, but the expense connected with their use seems to be so great that this method of protection cannot be considered practicable with fuel oil at the present price. The heaters were loaned to the substation by the Hamilton Orchard Heater Company, through the courtesy of its local agent, Mr. Chester D. Holmes of Plymouth, Mass.

3. Fungous Diseases.

As in previous years, this work was carried on in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture. Dr. C. L. Shear of that Bureau has done much laboratory work and has had general supervision of the spraying experiments, having kept in touch with the work on the bogs by several trips to the Cape. Co-operative spraying tests were carried on by several growers. The five plots, each four rods square, which were sprayed in the season of 1911, as reported in the last annual report of the station, were sprayed again in 1912 on dates and with fungicides as follows: —

TABLE I.

FUNGICIDE.	Plot A.	Plot B.	Plot C.	Plot D.	Plot E.
Bordeaux mixture, . . .	June 28	June 28	June 29	June 29	June 29
Bordeaux mixture, . . .	July 17	July 17	July 18	July 18	July 18
Neutral copper acetate, . .	August 5	August 5	August 6	August 6	August 6

The Bordeaux mixture was made up of 3 pounds of lime and 4 pounds of copper sulfate to 50 gallons of water. One pound of the neutral copper acetate was used to 50 gallons of water. Two pounds of resin fish-oil soap were used with the Bordeaux mixture in all cases and with the acetate.

The crop was gathered from these plots and their checks on dates and in amounts as follows, the quantities being given in bushels: —

TABLE II.

PLOT.	Area (Square Rods).	Date when picked.	Variety.	Quantity of Fruit (Bushels).	Quantity per Square Rod (Bushels).	Average of Double Checks per Square Rod.	Per Cent. of Increase due to Spraying.
A, . .	16	Sept. 19	Howe.	7⅛	.4453	-	144+
A check 1, .	4½	Sept. 19	Howe.	¾	.1667	.1823	-
A check 2, .	8	Sept. 19	Howe.	1 7/12	.1979		
B, . .	14⅛	Sept. 12	McFarlin.	7	.4956	-	45+
B check, .	13⅔	Sept. 12	McFarlin.	4⅔	.3415	-	-
C, . .	16	Sept. 19	Howe.	6⅙	.3854	-	86⅗
C check 1, .	4	Sept. 19	Howe.	⅞	.2187	.2065	-
C check 2, .	12	Sept. 19	Howe.	2⅓	.1944		
D, . .	16	Sept. 12	Early Black.	10⅓	.6458	-	47⅗
D check, .	8	Sept. 12	Early Black.	3½	.4375	-	-
E, . .	16	Sept. 7	Early Black.	7¾	.4841	-	55+
E check 1, .	8	Sept. 7	Early Black.	2½	.3125	.3125	-
E check 2, .	4	Sept. 7	Early Black.	1¼	.3125		

It will be noted from this table that the results of the spraying were far more marked with the Howe variety than with either of the others. Moreover, Plot A showed a much greater increase than the other Howe plot. The only difference in the treatment of the two Howe plots was that Plot A was sprayed three times during 1911, while Plot C, as well as the other plots, was sprayed only twice.

Where two checks were laid out for the same plot (as noted in the above table) they were in every case located on opposite sides of the sprayed area. The berries were all picked with scoops. It should be borne in mind that the increases recorded above were obtained in spite of considerable mechanical injury done in the process of spraying. The spraying was done with a 30-gallon wheeled-barrel outfit, and the injury was much greater than it would have been had a power outfit been used, it being serious enough to be plainly noticeable on the vines, on parts of the plots, at picking time.

It should be noted here that the fungus plots showed no increase in quantity of fruit over their checks last year, and this may perhaps be taken to indicate that the effects of annual spraying are cumulative.

The increase in quantity of fruit on the McFarlin plot was accompanied by a much more light-colored and sickly appearance to the foliage than was shown by the vines of the check plot. The contrast between the sprayed and unsprayed vines in this respect was noticeable by the 1st of September, and very marked after the crop was picked, being plainly evident to the eye from a long distance. A redder and more sickly color was also distinctly evident on the two Early Black plots as compared with the surrounding unsprayed vines, but the contrast was not nearly so great as with the McFarlin plot. No such difference was apparent on the Howe vines, possibly because it was hidden by the naturally very dark color of their foliage. The McFarlin and Early Black vines seemed to show that there was not sufficient available plant food present to maintain a strong vine condition and at the same time develop the extra amount of fruit which the reduction of fungous diseases by the spraying had made possible. Possibly the effects of fungus spraying are often limited by such a lack, and combination experiments with fungus spraying and fertilizers have been planned to determine this point.

When the fruit was gathered no distinct difference in color between the berries from the sprayed plots and their checks was observed. The berries from Plots A and C were somewhat larger than those from their checks, as shown by the following averages of counts of berries of 6 cupful samples (New England Cranberry Sales Company's inspector's cup) from each plot and its check, the samples being in each case taken as evenly as possible from the various boxes: —

		Number of Berries.
Plot A.	Average of first 6 samples,	100
	Average of second 6 samples,	105
Check A.	Average of first 6 samples,	110
	Average of second 6 samples,	104
Plot C.	Average of first 6 samples,	104
	Average of second 6 samples,	108½
Check C.	Average of first 6 samples,	112
	Average of second 6 samples,	111

The berries from the McFarlin plot showed practically no difference in size from those of the check, as is evident from the following averages of 6 samples taken in the same way: —

		Number of Berries.
Plot B.	Average of first 6 samples,	67
	Average of second 6 samples,	72
Check B.	Average of first 6 samples,	68
	Average of second 6 samples,	71

Of the Early Black plots, Plot D and its check showed practically no difference in the sizes of their berries, as is shown by the following averages of counts of 6 samples: —

		Number of Berries.
Plot D.	Average of first 6 samples,	110
	Average of second 6 samples,	109
Check D.	Average of first 6 samples,	111
	Average of second 6 samples,	109

The berries from Plot E were distinctly smaller than those from its checks, as is shown by the following averages: —

		Number of Berries.
Plot E.	Average of first 6 samples,	120
	Average of second 6 samples,	123
Check E.	Average of first 6 samples,	113
	Average of second 6 samples,	109

It should be noted here that the time of picking, apparently, had something to do with the relative size of the berries from these plots and their checks, for Plot E, picked on September 7, produced smaller berries than its checks, and Plots B and D, picked on September 12, produced berries of the same size as their checks, while Plots A and C, picked on September 19, produced larger berries than their checks, a gradation according to dates, irrespective of variety, thus being evident. This was perhaps caused by a retardation in the development of the fruit on the sprayed vines, due to the heavier crop which they were producing.

The keeping qualities of the berries from these plots and their checks were tested, with the results shown in the following table: —

TABLE III.

PLOT.	Test begun.	Test ended.	Quantity tested (Boxes).	Quantity of Sound Fruit after Screening (Boxes).	Percentage of Loss.
A, ...	Oct. 3	Dec. 16	3	2 5/8	12 1/2
Check A, ...	Oct. 3	Dec. 16	2	1 1/2	25
B, ...	Oct. 11	Dec. 16	2 2/3	2 7/64	21
Check B, ...	Oct. 11	Dec. 16	2 1/3	1 9/16	33
C, ...	Oct. 11	Dec. 17	4	3 19/32	10
Check C, ...	Oct. 11	Dec. 16	2 2/3	2 7/64	21
D, ...	Oct. 11	Dec. 16	3	2 17/32	15 3/5
Check D, ...	Oct. 11	Dec. 16	2 2/3	2 3/16	18
E, ...	Oct. 11	Dec. 16	3 1/3	2 23/32	18 2/5
Check E, ...	Oct. 11	Dec. 16	2 1/3	1 13/16	22 1/3

The boxes used were bushel boxes, but a few slightly smaller boxes got mixed in and were not noticed until too late, causing an error to creep in which undoubtedly affected the percentages somewhat, though it is impossible to say how much. The berries were run through the separator at the beginning of the tests, but were not screened until the final screening on December 16 and 17. For these tests the berries of the two checks of those plots which had double checks (A, C and E) were mixed to form a single check for each plot.

It will be noted that Table III. shows a much greater improvement of keeping quality, due to the spraying, with the Howe berries (A and C) than with either the Early Blacks (D and E) or the McFarlins (B). This and the distinctly greater increase in quantity of fruit on the Howe plots indicate the presence of a special diseased condition, affecting that variety, which was either much less in amount or absent altogether on the McFarlins and Early Blacks. While there was much more hypertrophy (" false blossom ") on the Howe vines during the first part of the summer than on the vines of the other varieties, it does not appear that this was the cause of the difference in the results obtained from spraying, for it has not been shown that spraying affects this disease. The difference seems to have been due to the presence of a hitherto unknown disease (as Dr. Shear has determined) which, for convenience, we will tentatively call the " blossom end rot." This disease was the most evident cause of decay among the Howe berries from the station bog in the fall of 1911 and also of 1912. It was only occasionally found, however, on the berries of the other varieties. Its characteristic effect on the fruit is to cause it to rot, beginning at the blossom end and working gradually toward the stem end, the berry becoming soft but remaining plump and watery, as the decay progresses. In an early stage of this rotting a characteristic, yellowish brown discoloration appears at or near the blossom end of the berry and remains there without much extension until the whole berry becomes soft. That the presence of this disease was the cause of the difference in the results obtained by spraying is shown by the following averages of counts of decayed berries in samples taken at random from the boxes of the storage tests (6 samples examined for each average), classified according to the apparent primary causes of the decay: —

TABLE IV.

[These examinations and counts were made on November 12.]

CAUSES OF DECAY.	PLOT A.		CHECK A.		PLOT C.		CHECK C.	
	First Average.	Second Average.	First Average.	Second Average.	First Average.	Second Average.	First Average.	Second Average.
Blossom end rot,	1⅔	3	6	1½	1	1	5	9
Injury,	-	1	3	1½	1	3	-	2
Doubtful,	2⅓	2	1	2	1	1½	-	3

Table III. indicates that Plot E and its check had larger percentages of loss in the keeping tests than did Plot D and its check. That this was true is also shown by the average counts of decayed berries in samples examined on November 11 given in the following table: —

TABLE V.

	Plot D.	Plot E.	Check D.	Check E.
Number of samples taken,	12	12	12	12
Average counts,	4⅙	7½	7½	9½

It might be thought that the difference here noted was due to the earlier picking of Plot E and its check, the greener fruit, perhaps, not keeping as well as that left on the vines until more mature. Close inspection of the results given in Tables II. and III. does not, however, sustain this view. Table III. indicates an improvement in keeping quality for Plot E of about 17⅗ per cent. over the check, while Plot D showed an improvement of only 13⅓ per cent. over its check. This, together with the fact that E gave an increase of 55 per cent. in quantity of fruit over its check while D gave an increase of only 47⅗ per cent., indicates that the greater amount of decay, among the berries from E and its check, in the keeping tests was due to the presence of a greater amount of fungous disease on that portion of the bog. The tests appeared to give no evidence that the stage of ripeness at which the berries were picked had any effect on their keeping quality.

Effect of Resanding on Prevalence of Fungous Disease.

A part of the station bog was resanded in 1911, and most of the remainder in the spring of 1912, with about half an inch of sand. Two Early Black plots (O and V) of 9 square rods each were left unsanded as an experiment, O being located on a portion of the bog sanded in the fall and V on a part sanded in the spring. Checks were laid out on three sides of each of these plots, and in both cases they averaged a distinctly smaller quantity of fruit per square rod in the 1912 crop than did the plots themselves. This difference was perhaps caused by the injury done to the vines in the process of sanding. The keeping qualities of the berries from these plots and their checks were tested with the results given in the following table: —

TABLE VI.

PLOT.	Test begun.	Test ended.	Quantity tested (Boxes).	Quantity of Sound Fruit after Screening (Boxes).	Percentage of Loss.
O,	Oct. 3	Dec. 13	1 2/3	1 7/17	15 3/10
Check O,	Oct. 3	Dec. 14	2	1 9/16	21 9/10
V,	Oct. 3	Dec. 13	2	1 11/16	15 3/5
Check V,	Oct. 3	Dec. 13	2	1 5/8	18 3/4

The same error crept into the measurement of these berries as that noted in connection with Table III. The berries were handled throughout in the same way as were those from the fungus spraying plots. The results seem to indicate that resanding favors fungous diseases.

As a check on the results obtained from the screening, shown in Table VI., the results of examination and counts, given in Table VII., are of interest. These counts were made on November 16. Each number given in Table VII. is the average of the counts of the decayed berries in 6 samples, taken in the same way as with the berries of the fungus spraying plots.

TABLE VII.

	Plot O.	Check O.	Plot V.	Check V.
First average of 6 samples, ...	6	10½	3½	5½
Second average of 6 samples, ...	9½	11	2½	10

These results seem to indicate that spring sanding favors fungous development more than does fall sanding. In this respect, the result is the reverse of that obtained from screening.

4. VARIETIES.

Investigations looking toward the possible production of new and more desirable varieties were continued. The uprights which had been marked on account of their prolificness in 1911 were found in 1912 to be, as a rule, either dead or barren. Only two or three of them bore more berries than the average, and these berries were much below the average in size. Because of the experience with these uprights an attempt was made to discover some of the more certain marks of cranberry prolificness. It now seems that the most noticeable and evident of these marks is the tendency and ability of the uprights of certain varieties to put out new uprights as branches, and at the same time develop from 3 to 5 berries each. A large number of such branching uprights were marked for examination next season. If they do exceptionally well it is planned to use the more prolific ones for planting. It should be noted here that the varieties most grown (Early Blacks, Howes, etc.) seldom produce branches on berry-bearing uprights.

In the fall, for the first time, tests of the comparative keeping qualities of certain varieties were made, and some interesting results were obtained which may eventually be of considerable value.

5. BLOSSOM FERTILIZATION.

The 1911 experiment of shutting out all bees from a small area of vines, during the blooming period and for some time afterwards, was repeated on another part of the bog in 1912. The screen was put in place over this area before a single blossom had opened and kept there until the last part of August.

Strange to say, the enclosed area bore about half as large a crop, per rod, as the surrounding bog. This result appears to contradict partially the results obtained in 1911, and for this reason it is planned to repeat the experiment again in 1913. A few small, solitary bees, or even honey bees or bumblebees, may have worked their way through the netting without being observed and visited a part of the blossoms.

The plot from which bees were excluded in 1911 has in all other respects always been treated like the surrounding bog. It is therefore of special interest to note that in 1912 this plot bore over twice as large a crop per square rod as the average of the rest of the bog, and a considerably larger one than any other equal area on the bog, the fertilizer and fungus plots included. In 1911 this area bore a very light crop in comparison with the rest of the bog. This seems to show that the after effects of light or heavy cropping often appear the following season. It is very desirable to determine to what extent this is true, for if it can be established that such effects generally do appear in the crop of the succeeding season, it must have a strong bearing on the management of cranberry bogs in more than one respect. If these effects are carried over, the apparent importance of keeping bees to insure good blossom fertilization is, in general, much reduced, for what a bog fails to produce in years of bee scarcity, on account of poor fertilization, it will tend to make up in years of bee abundance.

The keeping quality of the berries from this 1911 plot was tested, in comparison with the berries from some of the fertilizer plots. The results of the test were as follows: —

Table VIII.

Plot.	Test begun.	Test ended.	Quantity tested (Boxes).	Quantity of Sound Fruit after Screening (Boxes).	Percentage of Loss.
1911 Bee Exclusion Plot,	Oct. 11	Dec. 16	1/3	26/96	18 3/4
Fertilizer Plot 22,	Oct. 11	Dec. 14	2	1 7/16	28 1/8
Fertilizer Plot 21,	Oct. 11	Dec. 14	2	1 3/8	31 1/4
Fertilizer Plot 20,	Oct. 11	Dec. 16	2	1 1/2	25
Fertilizer Plot 1,	Oct. 11	Dec. 14	1 1/3	7/8	34 3/8
Fertilizer Plot 2,	Oct. 11	Dec. 14	2	1 13/32	29 7/10

These fertilizer plots were located near the bee plot and are here arranged in their order of proximity to that plot, 22 being the nearest and 2 the farthest away. Plot 22 is separated from the bee plot by not more than its own width, and 2 is not more than 8 rods away. Plots 1, 21 and 22 are all check fertilizer plots, and have been treated in all respects like the surrounding bog. The results indicate that the bee plot berries for some reason were much better keepers than were the berries of the surrounding bog.

The average counts of decayed berries in several samples taken from each of these plots give evidence of the general accuracy of the results shown in the above table. They were as follows: —

TABLE IX.

	1911 Bee Plot.	Fertilizer Plot 22.	Fertilizer Plot 21.	Fertilizer Plot 20.	Fertilizer Plot 1.	Fertilizer Plot 2.
Number of samples taken, .	4	8	8	8	8	8
Average counts, ...	8	16	18½	10½	20	14½

These counts were made between the 14th and the 22d of November.

The comparatively small percentage of loss among the bee plot berries shown in Table VIII. is surprising, in view of the fact that for some reason there was evidently a greater loss caused by the collapse of berries injured by fruit worms in this lot than in those from the fertilizer plots. In general, these results may perhaps be taken to indicate that the berries of a heavy cranberry crop will, other conditions being the same, keep better than those of a light

The berries from this bee plot showed other peculiarities as follows: —

First. — A marked comparative softness resembling the softness often characteristic of russet apples in the spring due to loss of water during long storage. This was so evident that the screeners noticed it at once on changing from other berries.

Second. — A large proportion of berries with rough areas on them, somewhat resembling the russeting of apples. These areas are peculiar to berries of the Early Black variety, being only occasionally found on Howes and McFarlins. Counts of berries having such areas in samples taken from different plots and varieties are given in the following table, as knowledge concerning this may have value: —

TABLE X.

PLOT.	Variety.	Number of Samples taken.	Berries with Rough Areas.	Berries without Rough Areas.
1911 Bee Exclusion Plot,	Early Black,	3	49 58 55	68 60 56
Fertilizer Plot 22,	Early Black,	2	26 30	73 81
Fertilizer Plot 15,	Early Black,	3	14 13 11	86 78 79
Plot B,	McFarlin,	1	4	66
Check B,	McFarlin,	1	7	72
Plot C,	Howe,	1	6	89
Check C,	Howe,	1	9	96
Plot D,	Early Black,	2	27 33	77 70
Check D,	Early Black,	2	31 28	67 78
Plot E,	Early Black,	1	18	90
Check E,	Early Black,	1	20	101

Note the much larger proportion of rough berries from the bee plot as compared with those from any of the other plots. Note also the much smaller proportion of such berries produced by fertilizer Plot 15 as compared with the other Early Black plots. Plot 15 was treated in 1911, and again in 1912, with 200 pounds of nitrate of soda, 400 pounds of acid phosphate and 200 pounds of high-grade sulfate of potash. Plot 22 was a check plot without fertilizer. Plots B, C, D and E were the sprayed fungus plots already discussed. The fact that the fruit from D and E was practically the same in this respect as that from their checks tends to indicate that the roughness was not caused by fungous disease. In the opinion of the writer it was caused (as is the russeting of apples) by the deposition of corky tissue in the skin of the fruit. Dr. Shear, in examining berries with these rough areas, found no fungus in connection with them. The difference, shown in Table X., between Plots D and E was probably due to the difference in the time of picking the berries.

These rough areas are usually more abundant among berries grown on "hard bottom" than among those grown on peat. Berries grown on "hard bottom" are usually, other conditions being the same, better keepers. This well-known fact, together with the experience with the berries from the bee plot here noted, suggests that the roughening of the fruit here discussed may be relied upon to some extent as an indicator of the keeping quality of Early Black berries. The fruit of the Late Howe variety is sometimes streaked with irregular, vein-like, red lines during ripening, and these lines appear to be of the same nature as the rough areas on the Early Black fruit, for they are most prevalent, as a rule, on berries grown on "hard bottom," and occasionally rough areas are associated with them, the roughness being superficial while the red veining is deeper within the tissues.

6. FERTILIZERS.

The Waquoit experiments were not continued, though the plots were examined just before harvesting and were found without exception to have produced a very light crop. There was apparently no evidence of any cropping effect from the fertilizers used in the preceding seasons.

The plots on the station bog at East Wareham were fertilized again, with the results shown in Table XI. The fertilizers were applied on June 25 and 26. The berries were all picked with scoops on September 11 and 12. They appeared so uniform in color and so alike in most other respects that no records were made, except those concerning their quantity, size and keeping quality. Storage tests were carried out with berries from all the plots, beginning October 11 and ending December 13 to 17, the results of which gave no evidence that any of the fertilizers, except perhaps the acid phosphate, had affected the keeping quality in any way whatever. There seemed to be somewhat less loss, as a rule, among the berries from the plots treated with phosphate (alone or in combination) than among those from the plots on either side of those so treated. The results in this connection, however, were not very positive.

TABLE XI.

PLOT.	Fertilizer used.	Quantity of Fruit obtained (Boxes).	Size of Berries; Average Number in 8 Samples.
1,	–	1⅞	109
2,	N	3¼	108
3,	P	2	105½
4,	K	1¾	112
5,	–	1¾	105½
6,	NP	3⅐	108½
7,	NK	3⅞	102
8,	PK	2¾	106½
9,	–	2⅓	110
10,	NPK	4	104
11,	NPKL	3½	105½
12,	NPKcl	3⅖	99
13,	–	2½	108½
14,	$N_{1\,1/2}$ PK	4⅚	105
15,	N_2 PK	6⅑	102½
16,	$NKP_{1\,1/2}$	5⅔	103½
17,	–	3⅙	106½
18,	NKP_2	5½	102
19,	$NPK_{1\,1/2}$	4	106½
20,	NPK_2	4⅕	103½
21,	–	3	105½
22,	–	3⅛	106
23,	–	2	106

Plots 1, 5, 9, 13, 17, 21, 22 and 23 are all untreated check plots. The meanings of the fertilizer symbols used are as follows: —

N means 100 pounds nitrate of soda per acre.
P means 400 pounds acid phosphate per acre.
K means 200 pounds high-grade sulfate of potash per acre.

L means 1 ton of lime (slaked) per acre.
KCl means 200 pounds muriate of potash per acre.
$N_{1\ 1/2}$ means 150 pounds nitrate of soda per acre.
N_2 means 200 pounds nitrate of soda per acre.

In combinations they mean, for example, as follows: N_2PK = 200 pounds of nitrate of soda + 400 pounds of acid phosphate + 200 pounds of high-grade sulfate of potash per acre.

The nitrate of soda evidently had a marked effect in increasing the quantity of fruit. As is shown by the figures in column four of Table XI. (the average sizes of the berries were inversely proportional to these figures), the variation in size between the berries from the different plots was not very great. The increases in quantity were evidently due for the most part to an increase in the number of the berries, the increase in their size being a minor factor. The potash caused no increase in fruit and the phosphate but very little. If the lime had any effect, it was detrimental. The boxes used in measuring this fruit were bushel boxes. The area of each of these plots is 8 square rods.

While the vines showed more growth on the plots to which the nitrate was applied than on the rest of the bog, this growth was not more than is desirable. There seem to be indications that the degree of drainage during the growing season has an influence on the action of nitrogenous fertilizers in their effects on fruit production and vine growth.

7. INSECTS.

The total cranberry insect injury of 1912 was greater than is usual on Cape Cod. The damage done by the fruit worm was more than in any season for four or five years before. The blackhead cranberry worm (fireworm) did greater and more general injury than in any season before for many years. The span worm caused serious injury for the first time in several years, destroying the crop and all the foliage on the greater part of the Old Colony bog at Yarmouth. The scale insect (*Aspidiotus oxycoccus* Woglum), discussed in last year's report as having done serious injury on a bog in Yarmouth, disappeared almost entirely, having been destroyed, apparently, by the winter flowage. It now seems evident that winter flowage is sufficiently detrimental to this pest to control it entirely, without any other treatment, if it is applied regularly every year and is held until May. The insect got its foothold on the Yarmouth bog in a season following a winter during which the bog was not flowed.

By correspondence the writer learned of serious injury on some Long Island bogs due, apparently, to the work of spittle insects, though it seems probable that other causes may have been contributory. The experience of the managers of these bogs indicates that complete reflowing for a day or two, when these insects are at work, will drive them out satisfactorily, and also that contact poisons may be used against them with considerable success where water for flowage is not available.

That the gypsy moth was abundant on bogs in places, especially in North Carver, was shown by the specimens sent in for determination.

The experimental insect work was confined mostly to the fruit worm and the blackhead cranberry worm (fireworm), though observations on the girdler ("root worm") were also made.

The Fruit Worm (*Mineola vaccinii* (Riley)).

Investigations concerning the effect of weather conditions at different seasons on fruit worm abundance were started, and the results of this work indicate the possibility of forecasting seasons in which great injury may be expected from this insect.

Late holding of the winter flowage is the surest method of controlling this insect so far known. The year's observations indicate that it is probably best to hold this flowage late (until May 25) every other year instead of every third or fourth year, as has been heretofore recommended. This is certainly true, if the effects of light and heavy cropping are generally carried over from one season into the next, as indicated by the results obtained on the 1911 bee experiment plot, for the reduction in the crop of one season, caused by the late holding of the water, will be largely made up the following year. This treatment is sure to greatly reduce the fruit-worm injury for the years of early withdrawal as well as for the years of late holding. Moreover, it seems probable that much of the fruit reduction, caused by ordinary late holding of the winter flowage, is really due to increased fungous injury, which might be largely prevented by proper spraying.

Early putting on of the winter flowage does not appear to affect the fruit worm much. A 10-acre bog, which lost most of its crop by this insect in 1911, was flowed for the winter on October 5, and the flowage was not let off until May 8. Even after this long flooding the fruit worms destroyed about 50 per cent. of what would otherwise have been a good crop.

Spraying, as a fruit-worm remedy, is still of doubtful practicability and probably always will be. The need of such a treatment, however, is not very great, for, as already stated, this insect can be treated with water where winter flowage is available, and the total acreage of bearing bog which cannot be winter-flowed at a reasonable expense is a very small percentage of the total bog area of the Cape. Moreover, most bogs which cannot be winter-flowed at a reasonable pumping expense are not and never were good business propositions for various reasons, and should never have been built in the first place. However, as there are a few such bogs which will pay a moderate return if the fruit worm is kept within bounds, it seems desirable if possible to find some treatment other than winter flowage for this insect.

A patch of 9 square rods on a dry bog badly infested with this insect was resanded on May 23 to a depth of 1 inch, the uprights being raked up through the sand when covered by it. It was thought that such sanding, while the insect was dormant in its winter cocoon, might smother it, as it does the girdler, so that the millers would not emerge during the following summer to lay eggs for another brood of worms. The sanded area was surrounded with a mosquito netting fence 8 feet high to keep the moths from the surrounding bog from coming onto it; but it was not closed in at the top, as it was necessary to give bees free access to the blossoms inside, and the moths, which apparently never fly up more than 5 or 6 feet from the ground, would probably not get in over the fence. Unfortunately, the new growth had started considerably when the sanding was done and, on this account, the injury to the buds was very severe, more than three-fourths of them being destroyed. Earlier sanding would have caused less injury. This experiment was only partially successful, as numerous fruit worm millers were seen inside the netting during the season, and probably 40 per cent. of the berries that developed on the sanded area were destroyed by the worms. That a large percentage of the millers was smothered is shown by the fact that at picking time there were noticeably more berries on the sanded area than on any equal area of the surrounding bog, in spite of the great injury done to the buds in the process of sanding. The amount of infestation on the bog where the sanding was done is shown in a general way by the fact that on a large part of the bog the worms destroyed all the berries after there had been a blossom and a fruit setting which should have produced not less than 60 barrels to the acre. As it seems probable that this sanding will also have some effect on next year's infestation, the experiment will be continued the coming season.

As strictly dry bogs are usually either winter-killed or badly spring-frosted about every two or three years, it seems probable that the best treatment for this insect on such bogs would be to destroy the remnant of the crop in the years when the severe injury from either frost or winter-kill occurs. This could probably be most readily done by spraying the bloom with a 20 per cent. solution of iron sulfate. The destruction of the bloom would cut off the season's local food supply for the insect, and it would naturally, for the most part, die off by starvation as a result. In most cases, this destruction of the bloom, after its severe reduction by adverse weather conditions, will not result in a loss to the grower, for, if the blossoms are left and the crop remnant is allowed to develop normally, the fruit worms, which without the interference of weather conditions would have an ample food supply, will be compelled to concentrate on the remnant, with the result that there will be little or nothing left at picking time anyway.

During the season following one in which a bog's infestation is starved out in this way, practically the only infestation present will be that which comes in from the upland, and that will probably not be very serious in most cases.

Another probable benefit from this method of treatment is that coming from not tearing up the vines in picking what little fruit might be left after the worms got through if the remnant of the bloom was not destroyed. *Probably more is lost, as a rule, through injury done to the vines, in harvesting a very light crop, than is gained by saving and marketing the berries.*

Work on fruit-worm parasites was continued, but without any definite results of general value.

The Flowed Bog Fireworm (*Rhopobota vacciniana* (Pack.)).

This insect is also known as the blackhead cranberry worm, but it will probably be more readily and generally recognized by the more distinctive name here used. It does little or no damage on bogs that are not winter-flowed. As indicated in the 1911 report, the killing or driving ashore of the natural enemies of this insect by the flowage is probably the main cause of serious infestation by it. In support of the evidence given in that report, the results of this season's collecting of bog insects seem rather convincing. Collections were made on several winter-flowed bogs of great difference in area, at different lengths of time after flooding and at different distances from the uplands, for comparison. Each collection consisted of the material gathered by 100 sweeps of a collector's net through the vines. Three separate collections were made on each day of collecting at each location selected for comparison, to make sure that the collections were truly representative of the insect life present. Comparisons between the different locations were made by separating out the parasitic and predacious forms, classifying them, counting the individuals of each class in each collection separately, and comparing the counts. The most remarkable fact learned from this was that, of all forms capable of damaging the fireworm, spiders were in all cases considerably the most numerous. Moreover, only the spiders gave really striking differences in the counts of the different collections made. The comparisons showed that the dry bog had very many more spiders and also a somewhat larger number of parasitic insects than did any of the winter-flowed bogs, even as late in the season as August 20, when the last collecting was done. A bog of 160 acres of rounded shape gave a distinctly smaller count of spiders, on all parts examined twenty-seven days after the flowage was taken off, than did a bog of 12 acres of similar shape on its very central portion sixty-eight days after the removal of the flowage. The distance from the center of the 12-acre bog to the upland at the nearest point is about 250 feet, as roughly measured by pacing. The 160-acre bog, in the material collected twenty-seven days after the flowage was taken off, gave distinctly larger counts and showed a greater variety of spiders near the upland than at the center. At the same time some kinds of parasitic insects were collected near the upland which seemed to be entirely absent at the middle of the bog. The distance from the center of this bog to the upland at the nearest point is about 750 feet, as measured by pacing.

While it is evident, therefore, that winter flowage seriously reduces the work of the natural enemies of the fireworm, especially on the large bogs, it must be remembered that in spite of this handicap they succeed in doing a great deal toward controlling this insect on all bogs and that, in the first beginnings of the most damaging infestation, only a few stragglers here and there succeed in escaping them. The escape of these stragglers is, however, a serious matter, for they increase the amount of infestation which these natural enemies must take care of the following season (a slight infestation probably coming onto the bog from the upland every year) if they succeed in keeping the pest under control. As the winter flowage comes in and sweeps away these natural enemies again, they cannot increase on the bog to meet the increase in the number of fireworms. The fireworms, therefore, tend to increase in number, while the number of their enemies tends to remain constant from season to season on account of the flowage interference (the bog is here considered as being winter-flowed, but not reflowed at a time to reduce the fireworms). When once the infestation has developed beyond the ability of the natural enemies of the insect to control it, its increase is very rapid unless artificial aids to these enemies are provided by man. Theoretically, the escape of 2 straggler fireworms one year may mean the escape of perhaps 50 the next year, and of perhaps 1,200 the third year, and of 30,000 the fourth year, and so on.

The point toward which we have been working in this discussion is this: *probably the ideal time to spray for this insect with arsenical poisons,* especially on the large compact bogs and on bogs which cannot be reflowed in June after having been winter-flowed, *is not after an infestation has fully developed and so threatens vines and crop that something must be done at once, but is before the infestation starts.* Cutting off the stragglers by spraying at the proper time every year, whether the insect appears to be present or not, will greatly retard the development of an infestation, if it does not completely stop it. Spraying for the stragglers need not be as effective as it would have to be under conditions of bad infestation, because the natural enemies of the fireworm will take care of most, if not all, of the worms which escape the poison. Unless the work of spraying for a heavy infestation is extraordinarily thorough and effective, there will be left, at best, a far greater number of unharmed worms than their natural enemies can begin to cope with.

Some will probably object to this method of treatment on the ground of expense. This, however, does not seem to be a valid objection when we consider that the prevention of the loss of a single average crop will make up for the expense of four good sprayings each year for a period of ten years. Then, too, as our spraying experiments, discussed in this report, have shown, most bogs should probably be sprayed several times each year to control fungous diseases. The fireworm spraying may be done at the same time, by using an excess of lime in making the Bordeaux mixture and adding a pound of Paris green to every 50 gallons, at an additional annual expense of perhaps $3.50 per acre.

While the prevention of infestation by this insect is important, it is necessary to consider how a fully developed infestation may be most easily cleaned out. As indicated in last year's report, the most serious obstacle usually encountered in ridding a bog of a bad infestation is the length of the hatching period, especially of the eggs that produce the first brood. This period seems to be much prolonged on bogs with thick vines, probably because the vines so shade the eggs on the lower leaves that their development is much slower than that of the eggs which, placed on the tops of the vines, are more exposed to the sun. In extreme cases, which are not uncommon, the hatching period is so much prolonged that there seems to be no time during the year when eggs of either the first or the second brood are not present in considerable numbers. When this period is not too much prolonged, it is often possible, at least on small bogs, to control a heavy infestation fairly well with either a single good spraying or a single early June reflowing.

The most successful treatment with water, all conditions considered, which the writer knows of, was applied on one of the large bogs during this season. The winter flowage was held until the 2d of June, from which date the bog was without flowage or any special treatment until the 25th of the same month, when it was completely reflowed for two days. Before this reflow the bog was heavily infested, but after it only a very few fireworms were seen throughout the season. This bog is compact in shape and covers about 160 acres. A considerable portion of it is heavily vined, and the infestation was spread pretty well over it. The most reasonable explanation of the success of this treatment appears to be the following one: —

In the water of the winter-flowage there was perhaps not so great a difference in temperature between the tops and the bottoms of the vines, especially where they were thick, as there would have been had they been exposed to the air as well as to the sun. Under these conditions all the fireworm eggs present were perhaps influenced in their development much more equally by the rising temperature of the spring days than they would have been without the flowage. The eggs were probably thus brought nearly to the hatching condition fairly well together, and then the water was taken off so that in this condition they were at once exposed to the hot weather of June, which naturally hastened rapidly the remaining development of all of them. By this means the hatching was so bunched up that when the bog was reflowed twenty-three days after the winter flowage was let off practically all the eggs, on thick vines as well as on thin ones, had hatched, and the insects were almost entirely in the caterpillar (worm) stage, the stage in which they are most readily drowned.

Possibly this method of treatment will not always prove as successful as it did in this case, but the conditions attending this trial were such that the results should probably be considered significant. This method should be tried further where badly infested bogs can be reflowed in June. Moreover, if the reasons given above for the success of this treatment are correct, it seems probable that spraying for a heavy infestation of this insect would be most successful if it were done after first bunching the hatching of the eggs by holding the winter flowage late. If the water is held late, the first spraying should be all done within a week after the flowage is taken off.

There is little doubt that any bog can be freed from this pest by treating it as a strictly dry bog for a few years (*i.e.*, not flooding it at any time under any conditions), thus allowing the natural enemies of the insect to accumulate against it, and at the same time spraying at proper times with arsenical poisons. The danger of loss from winter-kill and from fruit-worm infestation is, however, considerable under such conditions and must not be overlooked.

Small bogs can probably be rid of infestation by thorough spraying without omitting winter flooding.

The season's observations indicate that spiders (of several different species) and Tachina flies are the most numerous and useful of the natural enemies of the fireworm. Spiders attack and destroy the worms, and some of the jumping species have been seen to leap into the air after the millers. The Tachina flies lay the white eggs often seen on the worms, especially on and near their heads.

The Cranberry Girdler (*Crambus hortuellus* (Hübner)).

The season's observations on this insect sustain in every particular the conclusions concerning it reached in the past two years. A serious infestation by this insect, at least on a bog of small or medium size, is almost a certain sign of neglect. It apparently never succeeds in getting a foothold on bogs which are kept well sanded. Resanding every other year is usually sufficient to prevent infestation by it. Badly infested bogs almost invariably have an accumulation of old leaves over the sand under the vines, and usually the worst infestations are on heavily vined bogs.

There are indications that the girdler is often favored by man's flooding operations in the same way that the flowed bog fireworm is favored, — *i.e.*, by the destruction or driving ashore of its natural enemies. Winter-flowed bogs which cannot be reflowed appear to be more often seriously infested than do strictly dry bogs. It seems probable that neglect invites infestation by this insect because of the protection from its natural enemies afforded by the accumulation of dead leaves and other débris. Resanding covers up this material and probably compels the girdler worms to work under more exposed conditions.

Reflowing for a week or ten days right after picking is still a standard remedy for this insect where sufficient water is available.

8. MISCELLANEOUS.

In addition to the work already discussed, sanding and picking experiments have been started. In the former, the results of no resanding are being compared with those of resanding every year, every other year and once in three years. In the picking experiments hand picking is being compared with scoop picking and early picking with late picking, in their effects on the vines and on crop production. These experiments must be carried on for several years before very definite results from them can be reported.

Experiments to determine the effects of different weather conditions on the "setting" of the fruit were also started. A general weather record was begun with the idea of ascertaining the effects of different weather conditions at different seasons on cranberry growth, fruit production, insect enemies and fungous diseases.

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ENDING THE THIRTIETH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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TWENTY-FIFTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART II.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTIETH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE
AMHERST, MASS.

TWENTY-FIFTH ANNUAL REPORT.

PART II.

SUMMARY OF LEADING CONCLUSIONS.

FRED W. MORSE, ACTING DIRECTOR.

During the past eighteen years 371 varieties of potatoes have been tested. In all cases the varieties have been tried two successive years, and in the second year the seed has invariably been selected from the home-grown product of the previous season. The majority of the new varieties have proved inferior to the old standard sorts like Beauty of Hebron, Early Rose, Green Mountain and Irish Cobbler.

Varieties which have given high yields in more than one two-year test are Carman No. 1, Enormous, Simmon's Model, Steuben, New Satisfaction, Red River Early Ohio, Houlton Rose, I. X. L., Daughter of Early Rose, Rose No. 9, Dutton's Seedling, Fillbasket, White Elephant, Restaurant, Thorburn, Vanguard and Woodbury's White.

Eighty-two samples of seed were tested during the year for purity and freedom from weed seeds. Timothy gave an average purity test of 97 per cent., red clover, 97.6 per cent., red top, 98.4 per cent., alsike clover, 96.2 per cent., white clover, 94.8 per cent., and other seeds were equally good, although only one or two samples of a kind were received.

It has been found that different seed laboratories sometimes report widely varying results of germination tests, when they have worked independently upon samples from one large lot of seed. It has also been found to be difficult for the seed analyst to identify accurately different seeds so closely related as cabbage and cauliflower, while the identification of seeds of different varieties of one species is almost out of the question.

A simple tool has been devised for planting white-pine seed, by which the seeds may be quickly and easily inserted in the soil without waste of seed or back-breaking exercise.

The chestnut blight is working up through the Connecticut valley, making this region the worst infested of any portion of the State; but very few old trees with rough bark are found infected. There is an unusual amount of deterioration and dying out of chestnut, which is in no way related to the blight.

One or two applications of a solution of arsenate of soda will permanently kill weeds on tennis courts and poison ivy around trees and walls. It can be best applied with a sprinkling-pot to which is attached an apron to direct the spray.

Plantain and dandelions in lawns are not readily killed by cutting off the crowns, as a large percentage of plants are apt to renew their growth in a short time.

Frequent applications of fertilizers to lawns is an aid to suppression of weeds by promoting the growth of grasses. Pulverized manure is apt to introduce weed seeds if it is used instead of chemical fertilizers.

Mosaic disease of tobacco ("calico") is not a so-called "germ disease," but is due to a disturbance of the natural balance of forces within the plant. It is infectious and may be communicated from one diseased plant to another. Seed beds should either be properly sterilized by steam or allowed to grow to grass for a year or two if seedlings have shown the disease. Injury to the roots of plants when transplanting is a frequent cause of the development of the disease, and if a diseased plant is handled during the setting there is danger of a large number of plants being infected by the hands of the planter.

An exact record of the cost of food used in milk production, has been kept for years at the experiment station. Since 1908 the average annual cost for food has been $99.52 per cow, and practically 4 cents per quart for milk. To this amount must be added the cost of care and housing. In a comparison of oats with corn as a cattle food it has been found that the oats increased the food cost of milk about 3.5 per cent. over the cost where corn was used. It is believed that oats are not an economical food for milk production in this State.

At times potatoes are plentiful and cheap, and farmers have used them as food for stock. Complaints have been received at the experiment station that when potatoes have been fed they have caused a shrinkage in milk flow and other undesirable results. Experiments were tried which showed that potatoes may be used advantageously up to an amount of 25 pounds daily per cow.

Experiments with molasses as a food for live stock have shown that it does not improve the digestibility of the other foods which must be fed with it. Nevertheless, it is a cheap food, useful in fattening animals and in making rough fodder more palatable; but in comparison with corn meal, molasses possesses no advantages in price or efficiency. Molasses feeds should be carefully considered with regard to guarantees and cost in comparison with other concentrates before they are purchased.

Experiments with beet pulp have shown it to be an economical and efficient food for milk production when it can be purchased for a lower price than corn meal. Milk producers who purchase all their grain will find dried beet pulp a satisfactory component of the grain ration, up to one-half of the total mixture.

Several instances of failure of greenhouse crops, particularly cucumbers, have been brought to the attention of the experiment station. Analyses of the soil have shown it to be overloaded with soluble fertilizer, in comparison with soil in which the crops have made a normal growth. This overloading may have been due to too heavy dressing with manure and chemicals, or to unsatisfactory drainage, which permitted an accumulation of salts that in the favorable soil were leached out during the season.

The refuse tobacco stalks on an acre of tobacco have been found to contain over 87 pounds of nitrogen, 132 pounds of potash and 20 pounds of phosphoric acid, worth about $24 when compared with other standard waste vegetable matter like castor pomace. The common practice of spreading the stalks on the field to be leached by the rain and snow recovers a little more than half of the nitrogen and potash and practically none of the phosphoric acid. The stalks should be cut or shredded and plowed under, so that all the fertility may be recovered, while over 1¼ tons of vegetable matter may be incorporated with the soil to form humus.

During the year nearly 400 different insects were inquired about by the people at large. The season was especially favorable for the development of plant-lice, and over a hundred separate inquiries were received regarding these insects.

The discovery, in a box of celery from California of 50 individuals of a species of lady beetle belonging on the Pacific coast shows how injurious insects also may be imported and added to our list of garden pests.

Tests of new insecticides did not show them to be in any way superior to established kinds.

A VARIETY TEST OF POTATOES.

E. F. GASKILL.

During the last eighteen years the agricultural department of the experiment station has tested 371 varieties of potatoes. This work has brought out many interesting facts. It will not be possible in this article to go into all the details of the work, but the general plan and some of the more interesting facts will be given.

General Plan. — There have been in all cases two trials, — a preliminary test and a final test. The varieties selected each year for trial have been those advertised by different seedsmen and recommended to the public because of their superior merits. Small amounts of seed have been obtained from these firms and planted in one of our fields to produce seed for a second-year test. Thus for the second trial we have had home-grown seed that has been raised and stored under precisely the same conditions for every variety. During the preliminary tests records have been kept, but all of our conclusions are based upon results obtained in the second-year tests.

We have included in each trial, for the sake of comparison, some of the standard varieties, such as Beauty of Hebron, Green Mountain, Early Rose and Irish Cobbler.

Soil. — In most instances these trials have been made on a medium loam with a gravelly subsoil, affording good drainage and an ideal potato soil.

Fertilizers. — A home-made mixture has been used, furnishing the elements of plant food in about the following proportions: —

	Per Cent.
Nitrogen,	2½ to 4½
Phosphoric acid,	6 to 10
Potash,	8 to 10

Seed. — The original seed has come from widely different sources, but that used in the second-year tests has always been of our own raising. The practice has been to cut the tubers into pieces, having two eyes each and of as nearly equal size as possible. The seed has usually been treated for scab with either corrosive sublimate or formalin (two ounces of corrosive sublimate to 15 gallons of water, or one-half pint of formalin to 15 gallons of water).

Spraying. — Careful attention has been given to this phase of the work, using both a fungicide and an insecticide several times during the season.

A Few of the Varieties Grown.

In each of the following cases the five varieties giving the best yield are mentioned in the order of their superiority, and the five varieties giving the poorest yield are mentioned in the order of their inferiority.

In 1896, 60 varieties were grown, 14 of which gave yields of over 275 bushels per acre and 4 less than 150 bushels per acre.

Best. — Carman No. 1, Dutton's Seedling, Early Maine, Fillbasket, New Satisfaction.

Poorest. — Early Ohio, Polaris, World's Fair, Sir William, Alexander's Prolific.

In 1898, 25 varieties were grown, 11 of which gave yields of over 200 bushels per acre and 5 less than 150 bushels per acre.

Best. — White Elephant, Fillbasket, Enormous, Woodbury's White, Thorburn.

Poorest. — Early Maine, Bliss's Triumph, Dakota Red, Empire State.

In 1899, 94 varieties were grown, 48 of which gave yields of over 300 bushels per acre and 3 less than 200 bushels per acre.

Best. — Fillbasket, White Elephant, Washington, Howard, Enormous.

Poorest. — Empire State, Olgoma, Commercial, Hurst, Mills Long Keeper.

In 1902, 33 varieties were grown, 10 of which gave yields of over 250 bushels per acre and 4 less than 150 bushels per acre.

Best. — Beauty of Hebron (first generation from Maine seed), Beauty of Hebron (second generation from Maine seed), I. X. L., Steuben, Early Nancy.

Poorest. — Livingstone, Stevens, The June, Ford, 1902, Smith's Six Weeks.

In 1904, 49 varieties were grown, 12 of which gave yields of over 250 bushels per acre and 4 less than 150 bushels per acre.

Best. — Simmon's Model, Extra Early White Rose, Great Divide, Steuben, Maxima.

Poorest. — Kaiser Krone, White Ohio, Sweet Home, King of Ohio, Clinton.

In 1906, 25 varieties were grown, 4 of which gave yields of over 200 bushels per acre and 4 less than 100 bushels per acre.

Best. — Simmon's Model, Climax, Chenango White, Hammond's Wonderful, Gortsap.

Poorest. — Banner, Noroton Beauty, Short Seasons, Good as Gold, Uncle Gideon's Quick Lunch.

In 1907, 41 varieties were grown.

Best. — White Mountain, Green Mountain, Violet Mammoth, Green Mountain (Early Dying Tops), Manistie.

Poorest. — Imperial Early Ohio, Dan Patch, Fast Mail, Early Six Weeks, May's Netted Gem.

In 1909, 46 varieties were grown, 9 of which gave yields of over 275 bushels per acre and 5 less than 150 bushels per acre.

Best. — Burbank, Quaker City, Great Bonanza, Wilson's First Choice, Ionia Seedling.

Poorest. — Dew Drop, Snow White, Salzer's Prosperity, Perfection, Blush.

In 1911, 31 varieties were grown, 6 of which gave yields of over 200 bushels per acre and 12 less than 150 bushels per acre.

Best. — Red River Early Ohio, Good News, White Victor, Jumbo, Late Hebron.

Poorest. — 1910 Seedling, Early Bovee, Saxony, Sunrise, Surprise.

The following varieties have been included in two of our two-year tests and given very satisfactory yields each time: —

Carman No. 1, Enormous, Simmon's Model, Steuben, New Satisfaction, Red River Early Ohio, Houlton Rose, I. X. L., Daughter of Early Rose, and Rose No. 9.

The following varieties have been included in three of our two-year tests and given very satisfactory yields each time: —

Dutton's Seedling, Fillbasket, White Elephant, Restaurant, Thorburn, Vanguard, Woodbury's White.

Beauty of Hebron and Early Rose have been included in six of our two-year tests, and always stood among the ten or twelve best varieties each year. Some years they have stood among the first five.

The Green Mountain has been included in three of our two-year tests and has always given a very satisfactory yield.

A Few of the Interesting Facts brought out.

1. The rate of yields obtained have been from 66 to 509 bushels per acre.

2. The same variety is sometimes sold under more than one name.

3. The majority of the new varieties are inferior to the old standard sorts, like Beauty of Hebron, Green Mountain, Early Rose and Irish Cobbler.

4. Several good varieties have been discovered from the standpoint of both yield and quality.

5. Results obtained in the preliminary tests do not correspond with the results obtained in the second-year tests.

6. In testing varieties of potatoes it is absolutely essential to use seed that has been grown and stored under similar conditions. To prove this statement the following test was made: —

Seed of two standard varieties — Beauty of Hebron and Early Rose — were secured from several different sources. The source of seed and the results obtained are shown in the following table quoted from the report of the agriculturist in the eleventh annual report of this station: —

Comparison of Seed Potatoes from Different Localities (Yield in Pounds of 40 Sets).

Source of the Seed.	Varieties.			
	Beauty of Hebron.		Early Rose.	
	Merchantable.	Small.	Merchantable.	Small.
Home grown,	30.0	2.5	25.0	2.9
Guelph, Ontario,	32.3	1.8	–	–
Pennsylvania grown, Dreer,	24.5	3.3	27.5	3.5
James J. H. Gregory, Marblehead, Mass.,	35.5	2.5	–	–
Cornell Experiment Station, Ithaca, N. Y.,	29.3	2.5	31.0	2.0
Wisconsin, Olds Seed Company,	26.0	4.5	–	–
Maine, A. H. Weeks Company,	33.3	2.8	–	–
Dibble Seed Company, New York,	26.5	3.8	32.5	2.0
Minnesota, Farmer Seed Company,	–	–	21.0	3.8
Kansas, F. Barteldes & Co.,	–	–	20.0	7.8

7. Northern-grown seed is preferable to home-grown seed.

8. Many varieties advertised by seedsmen as being extra early or extra large yielders are found to be late and inferior in regard to yield.

9. From our observations the following varieties appear to be identical: —

King of the Earliest and Early Ohio.
Salzer's Earliest and Bliss's Triumph.
Miller's Banner and Livingston's Banner.
White Beauty and Cambridge Russet (almost identical).
Hammond's Wonderful and Rough Rider.
Million Dollar and Mark Hanna.

In discussing variety tests of potatoes in the fifteenth annual report of the experiment station, Dr. Brooks concludes as follows: —

> It is firmly believed that it is much wiser that potato growers shall secure seed of standard varieties grown and stored under the best conditions, than to pay high prices for new varieties, which in so many instances when carefully tested under the fairest possible conditions are found not to equal the older sorts either in productiveness or in quality. In our experience seed grown in northern Maine has invariably been found to be superior to that of our own production, even in the first generation. The Maine seed gives the larger yield, and the crop is somewhat earlier. It usually costs somewhat more than home-grown seed, but it is richly worth the greater price.

Preliminary Test, 1912.

During the past year, seed of nineteen varieties of potatoes was obtained from widely different sources. The seed was treated for scab, cut and planted in the usual way. The yields ranged from 91 bushels to 312 bushels per acre. The varieties grown were: —

Buckbee's Extra Early Rockford.
Clyde.
Diamond.
Early Six Weeks.
Early White Albino.
Farmer Potato.
Gray's Mortgage Lifter.
Green Mountain.
Johnson's Early Flour Ball.
Northern Star.
Quick Crop.
Sir Walter Raleigh.
Six Weeks.
Snow.
Sutton's Early Monarch.
The Early Surprise.
The Irish Cobbler.
The Petoskey.
Trust Buster.

In 1913 the second-year test will be made of these varieties using the seed grown in this year's test.

SEED WORK FOR THE YEAR 1912.

G. E. STONE.

The seed work for 1912 has included as usual seed germination, separation and testing for purity. There were 285 samples of seed sent in for germination, onion and tobacco leading the list. The average germination of onion seed for 1912 was 75.3; the highest being 95 per cent. and the lowest 7 per cent. The average for tobacco was 51.9; the highest 98 per cent. and the lowest 0. Last season (1911) the average germination of onion seed was 70 per cent.; the highest, 98 per cent., and the lowest 20 per cent. For tobacco the average was 84 per cent.; the highest, 95 per cent., and the lowest, 21 per cent. The average germination for onion seed was slightly below that given for a number of years, and that for tobacco was much less, due no doubt to the effects of frost on the seed.

Records of Seed Germination for 1912.

NAME OF SEED.	Number of Samples.	PER CENT. OF GERMINATION.		
		Average.	Highest.	Lowest.
Onion,	104	75.3	95.0	7.0
Tobacco,	50	51.9	98.0	0.0
Clover,	29	86.4	99.0	55.0
Grasses,	29	85.2	97.5	20.5
Cabbage,	10	57.0	85.0	6.0
Carrot,	9	59.3	90.0	31.0
Oats,	7	83.1	98.0	50.0
Sweet pea,	7	23.7	85.0	4.0
Turnip,	5	63.8	91.0	0.0
Corn,	4	46.6	63.0	37.0
Beet,	3	77.7	91.0	70.0
Squash,	3	49.7	62.0	41.0
Miscellaneous,	25	38.6	96.0	0.0
Total,	285			

The number of pounds of seed separated is not so large as last year, although the number of samples is greater. The total number of pounds separated was 1,517, about 1,300 pounds of it being onion seed. The percentage of seed discarded was from 11 to 19 per cent., the largest amount being discarded from lettuce seed. Practically all the lettuce seed received for separation is sent in by the market-gardeners around Boston.

Records of Seed Separation, 1912.

Name of Seed.	Number of Samples.	Weight (Pounds).	Per Cent. of Seed retained.	Per Cent. of Seed discarded.
Tobacco,	81	51.37	88.70	11.30
Onion,	54	1,298.62	88.10	11.90
Lettuce,	6	133.62	80.06	19.94
Celery,	4	1.38	86.40	13.60
Beet,	1	27.56	81.60	18.40
Radish,	1	5.51	83.20	16.80
Totals,	147	1,517.88		

The number of purity tests made during the year was 82, the seed coming in some cases from farmers, and in others from seed merchants. Occasionally farmers buy their seed, or decide not to, on the strength of these tests.

More purity tests were made of timothy than of any other seed, 17 samples being tested, followed by 11 for red clover and 11 for red top. The total number of species of foreign seed found in these tests was 51, 34 being regarded as noxious and 17 as harmless. These foreign seeds are by no means abundant, and are often difficult to remove even by the most improved methods of seed separation.

Records of Seed Purity Tests, 1912, made by E. A. Larrabee.

[Figures in parentheses indicate number of samples in which corresponding seed is found.]

Name of Seed.	Number of Samples.	Per Cent. Purity.			Kind of Weed Seeds found and Number of Samples in which found.	
		Maximum.	Minimum.	Average.	Noxious.	Harmless.
Timothy,	17	99	83.3	97.0	Pepper grass (5). Sheep sorrel (4). Lamb's quarters (5). Wild teasel (3). Cerastium sp.? (3). Chickweed (1). Potentilla sp.? (3). Ox-eyed daisy (1). Plantain (3). Yellow foxtail (1). Mustard (1). Curled dock (1). Knot grass (1).	Red top (5). Alsike clover (8). White clover (3). Poa sp.? (6). Red clover (3). Blue grass (1).
Red clover,	11	99	96.0	97.6	Plantain (8). Curled dock (3). Shepherd's purse (1). Chickory (1). Twistle (2). Wild carrot (2). Lady's thumb (1). Lamb's quarters (3). Barnyard grass (1). Charlock (1).	Alsike clover (2). Timothy (4). Alfalfa (4). Medic (3). Crimson clover (1). Red top (1).
Red top,	11	99	94.7	98.4	Sheep sorrel (4). Curled dock (2). Chickweed (1).	Timothy (3). Blue grass (1).
Oats,	4	99	98.5	98.8	Mustard (1). Yellow foxtail (1).	Corn (1). Wheat (3).
Alfalfa,	5	99	97.0	98.4	Plantain (3). Lamb's quarters (2). Sheep sorrel (1). Green foxtail (2). Yellow foxtail (1). Bindweed (1). Chickory (1). Thistles (1).	Red top (1). Poa sp.? (1). Medic (1). Panicum sp.? (1).
Alsike clover,	8	98	95.2	96.5	Mustard (1). Gum plant (1). Sheep sorrel (3). Lamb's quarters (3). Ox-eyed daisy (1). Chickory (1). Self-heal (1). Plantain (2). Chickweed (1). Yellow foxtail (1). Curled dock (3). Shepherd's purse (2). Thistle (1). Pepper grass (1). Seed unidentified (1).	Red clover (7). Timothy (7). Rabbit-foot clover (1).
White clover,	7	99	90.7	94.8	Sheep sorrel (6). Dock (1). Plantain (4). Chickory (1). Bouncing Bet (1). Crane's bill (1). Yarrow (2). Seed unidentified (2).	Medic (2). Alsike (3). Red clover (2). Red top (1). Timothy (2). Wild buckwheat (1).

Records of Seed Purity Tests, 1912, made by E. A. Larrabee — Concluded.

[Figures in parentheses indicate number of samples in which corresponding seed is found.]

Name of Seed.	Number of Samples.	Per Cent. Purity.			Kind of Weed Seeds found and Number of Samples in which found.	
		Maximum.	Minimum.	Average.	Noxious.	Harmless.
Kentucky blue grass.	3	98	96.0	97.0	Sheep sorrel (2). Lady's thumb (1). Plantain (1). Seed unidentified (1).	Red clover (2). Sweet clover (1). Alsike clover (1). Timothy (1). Red top (1).
Alfalfa clover, .	2	99	98.0	97.0	Yellow foxtail (1). Thistle (1).	Red clover (1).
Millett, . .	4	99	99.0	99.0	Lady's thumb (2). Curled dock (1). Plantain (1). Charlock (1). Penn Persicaria (2). Lamb's quarters (1).	
Rhode Island Bent,	3	97	96.0	96.7	Sheep sorrel (2). Switch grass (1).	Timothy (1).
Wood meadow, .	2	98	96.0	97.0	. . . . . .	Sweet clover (1).
Mammoth clover,	1	99	99.0	99 0		
Medium clover, .	1	99	99.0	99.0	Sheep sorrel (1). Lady's thumb (1).	
Lawn grass, . .	3	–	–	–	Sheep sorrel (2). Plantain (3). Buttercup (3). Curled dock (1). Pepper grass (2). Amaranthus sp.? (1). Chickweed (1). Field dodder (1). Seed unidentified (1). Dandelion (1).	

In this table rib grass and bracted plantain were put under the one title, "plantain."

The standard of purity frequently adopted for timothy is 98 per cent.; for red clover, 98 per cent.; for red top, 95 per cent.; for oats, 99 per cent.; for alfalfa, 98 per cent.; for Alsike clover, 95 per cent.; for white clover, 95 per cent.; for Kentucky bluegrass, 90 per cent. Nineteen samples of timothy gave an average purity test of 97 per cent.; 11 samples of red clover, 97.6 per cent.; 11 samples of red top, 98.4 per cent.; 4 samples of oats, 98.8 per cent.; 5 samples of alfalfa, 98.4 per cent.; 8 samples of Alsike clover, 96.2 per cent.; 7 samples of white clover, 94.8 per cent.; 3 samples of Kentucky bluegrass, 97 per cent.

It is clear that these seeds are of very high grade, some of them being much better than the standard required. Many of the so-called noxious weeds are of little importance with us and make slow headway in a well-seeded field, even Canada thistle, which greatly concerned the farmers many years ago, having become a relatively rare pest.

All samples of seed to be tested or separated should be sent to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass., and the freight or express should be prepaid.

SOME VARIABLE RESULTS OF SEED TESTING.

G. E. STONE.

The enactment in several States of various seed control laws, many of which are strict, has offered opportunity to study the accuracy of our whole system of seed testing. It has often been a question, particularly among the seed dealers, whether we are in a position to pass and enforce stringent seed laws. Accompanying the laws there is usually given a standard for the purity and germinating capacity of seeds. If seeds are improperly labeled, contain certain noxious weed seeds or fall below the standards given, according to the phrasing of some laws the seed dealer is liable to a fine.

Very different results are often obtained in seed-testing laboratories, it often requiring duplicate tests to obtain anything approaching the true averages. The results given in the following six tables were obtained by a large seed firm which collected a number of typical samples from bulk and sent them to several seed-testing stations for examination. The tables include tests of timothy, millet, Kentucky blue grass, orchard grass, alfalfa and red clover. The numbers in the first column of each table indicate the different seed-testing stations; for example, in the case of red clover, 19 different laboratories reported, and in nearly all cases germination and purity tests were made of each seed.

Table showing Purity and Germination Tests made at Different Seed-testing Stations of Seed taken from the Same Bulk (Data given in Percentages).

Red Clover.

SEED-TESTING STATION.	PURITY TEST.			Germination Test.
	Pure Seed.	Inert Matter.	Foreign Seed.	
1,	99.02	.80	.180	90.0
2,	99.15	.59	.260	87.5
3,	98.10	1.70	.200	84.0
4,	–	–	–	92.0
5,	98.40	1.20	.400	89.5
6,	–	–	.090	88.8
7,	99.50	.20	.300	95.0
8,	98.97	.68	.350	98.0
9,	99.70	.20	.100	84.0
10,	99.00	.80	.200	86.0
11,	98.70	.90	.400	–
12,	–	–	–	94.0
13,	98.50	.10	.400	86.0
14,	97.80	1.80	.400	91.0
15,	99.00	.99	.002	91.0
16,	98.88	.94	.180	93.0
17,	99.75	–	–	96.0
18,	98.90	.40	.700	96.0
19,	99.30	.40	.300	90.0
Average,	98.91	.73	.278	90.8

Timothy.

SEED-TESTING STATION.	Pure Seed.	Inert Matter.	Foreign Seed.	Germination Test.
1,	99.43	.35	.220	93.0
2,	99.41	.49	.100	96.7
3,	98.50	.40	.100	95.0
4,	–	–	–	93.0
5,	99.60	.30	.100	94.5
6,	99.00	.70	.300	90.0
7,	99.90	.05	.045	97.0
8,	99.60	.20	.200	86.0
9,	99.30	.50	.200	94.0
10,	99.30	.30	.400	–
11,	–	–	–	89.0

Table showing Purity and Germination Tests made at Different Seed-testing Stations of Seed taken from the Same Bulk (Data given in Percentages) — Continued.

Timothy — Concluded.

Seed-testing Station.	Purity Test.			Germination Test.
	Pure Seed.	Inert Matter.	Foreign Seed.	
12,	99.40	.20	.400	92.0
13,	99.50	.25	.250	92.0
14,	99.90	trace	trace	97.0
15,	–	–	–	90.0
16,	99.25	.30	.450	91.0
17,	99.76	–	–	94.0
18,	98.20	.10	1.700	90.0
19,	99.50	.30	.200	89.0
Average,	99.35	.30	.343	92.4

Millet.

Seed-testing Station.	Pure Seed.	Inert Matter.	Foreign Seed.	Germination Test.
1,	96.33	.45	3.22	93.0
2,	98.15	.22	1.63	90.0
3,	98.00	.20	1.80	87.0
4,	–	–	–	95.0
5,	98.20	.40	1.40	90.5
6,	–	–	3.43	92.9
7,	97.20	.50	2.30	99.0
8,	98.37	.20	1.43	99.0
9,	98.80	trace	1.20	93.0
10,	97.40	.20	2.40	94.0
11,	98.10	.40	1.50	–
12,	–	–	–	95.0
13,	98.20	.40	1.40	92.0
14,	98.08	trace	1.92	92.0
15,	97.40	.40	2.20	89.0
16,	98.60	.20	1.20	94.0
17,	97.55	–	–	96.0
18,	97.10	.30	2.60	90.0
19,	98.30	.40	1.30	96.0
Average,	98.48	.32	1.93	93.1

Table showing Purity and Germination Tests made at Different Seed-testing Stations of Seed taken from the Same Bulk (Data given in Percentages) — Continued.

Kentucky Blue Grass.

SEED-TESTING STATION.	PURITY TEST.			Germination Test.
	Pure Seed.	Inert Matter.	Foreign Seed.	
1,	88.15	11.55	.30	88.0
2,	78.90	21.10	.00	58.0
3,	89.00	10.60	40	78.0
4,	72.00	–	–	28.0
5,	81.70	15.00	.30	39 0
6,	–	–	.01	24.0
7,	86.60	13.00	.40	70.0
8,	99.59	.40	–	15.0
9,	99.60	.40	trace	–
10,	84.00	15.60	.40	66.0
11,	95.60	3.60	.80	–
12,	–	–	–	68.0
13,	78.40	21.50	.10	–
14,	96.90	3 10	trace	6.0
15,	–	–	–	73 0
16,	84.00	15.79	.20	78.0
17,	96 50	3.00	.50	7 5
18,	97.83	–	–	3.0
19,	98.70	1.10	.20	81 0
20,	83.80	16.00	.20	88 0
21,	–	–	–	32 (check)
Average,	84 36	10 11	.29	54.0

Orchard Grass.

1,	76.48	23.37	.15	81.0
2,	75.69	23.32	.99	82.0
3,	81.30	18 00	.70	91.0
4,	74.00	–	–	69.0
5,	74.50	24 50	1 00	70.0
6,	–	–	.07	69.2
7,	84.50	15.00	.50	76.0
8,	99.40	.40	.20	60.0
9,	97.60	2.00	40	–
10,	77.00	22.20	.80	80.0

Table showing Purity and Germination Tests made at Different Seed-testing Stations of Seed taken from the Same Bulk (Data given in Percentages) — Concluded.

Orchard Grass — Concluded.

Seed-testing Station.	Purity Test.			Germination Test.
	Pure Seed.	Inert Matter.	Foreign Seed.	
11,	93.90	5.30	.80	–
12,	–	–	–	86.0
13,	78.10	21.00	.90	81.0
14,	–	–	–	61.0
15,	76.50	23.50	–	59.0
16,	77.45	21.47	1.09	86.0
17,	–	–	–	65.0
18,	94.00	5.00	1.00	72.0
19,	93.17	–	–	50.0
20,	98.20	1.40	2.00	89.0
21,	90.60	8.60	.80	64.0
Average,	84.73	14.33	.76	73.2

Alfalfa.

Seed-testing Station.	Pure Seed.	Inert Matter.	Foreign Seed.	Germination Test.
1,	99.20	.52	.280	99.0
2,	99.33	.43	.240	94.0
3,	98.50	1.40	.100	95.0
4,	–	–[1]	–	98.0
5,	99.00	.30	.100	95.0
6,	–	–	.080	96.0
7,	99.10	.30	.600	93.0
8,	99.46	.27	.262	97.0
9,	99.20	.60	.200	92.0
10,	97.30	2.40	.300	97.0
11,	98.80	1.00	.200	–
12,	–	–	–	96.0
13,	99.40	.60	.200	95.5
14,	97.20	2.80	–	98.0
15,	94.10	5.90	–	99.0
16,	–	–	–	93.0
17,	98.82	1.00	.180	96.5
18,	99.86	–	–	98.0
19,	97.90	1.80	.300	95.0
Average,	98.47	1.37	.234	96.5

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[1] Grade No. 3.

From an examination of the data shown in the tables it will be seen that there are considerable differences in the results obtained by the various seed-testing stations. If we compare the highest and lowest percentages in each table for purity and germination tests we find the following results: the greatest variation in the percentage of pure seed in red clover was 1.7 per cent.; that for germination, 14 per cent. This sample was reported on by 19 different testing stations.

In the sample of timothy, 19 stations gave a difference of 1.7 per cent. in the purity tests and 11 per cent. for germination. In 18 station tests of millet there was a difference of 2.5 per cent. in the purity and 12 per cent. in the germination tests. Twenty-one tests of Kentucky blue grass gave a difference of 27.6 per cent. in the purity and 85 per cent. in germination tests. Twenty-one tests of orchard grass showed a difference of 25.4 per cent. for purity and 41 per cent. for germination. In the sample of alfalfa, tested by 18 different stations, there was a difference of 5.7 per cent. in purity and 7 per cent. in germination.

The maximum differences given in the purity tests are in most cases unimportant, 1 or 2 per cent. variation showing careful work; but differences of 5 or 10 per cent. or more are serious to the seedsman when he is required to conform to certain laws. This is also true of the germination tests, 2 or 3 per cent. or more being of little account, but when the differences range from 10 to 85 per cent., it is food for thought. Kentucky blue grass and orchard grass showed the greatest variations in the tests, but the purity tests, as might be expected, ran more evenly than the germination. The results given in these tables are by no means unusual, as greater differences in tests of the same sample from various seed-testing stations have previously been observed. On receiving results like these it is quite natural for the seedsman to ask what is the right course to follow, and which report he shall take as a basis for the guarantee under which he shall sell such seed as Kentucky blue grass and orchard grass. It is well known that there is a great deal of variation in the seed itself, due quite often to climatic conditions. The tests also vary greatly, even when the same methods are used, from different causes, and from the results given in these tables it would seem unjust to hold seedsmen to any rigid standard, as it would be likely to affect materially agricultural interests. For instance, the germination percentage of Kentucky blue grass ranges from 3 to 88 per cent., the average being 54 per cent., and it is a vital question to the seedsmen just what germination percentage the seed should have, as some of the lower percentages may be due to faulty methods. Too great pains cannot be taken in testing seeds for dealers when they are to be sold on merely a verbal guarantee, as there is a possibility of doing them great injustice and injuring their business.

Some of the laws which have been drawn up are rather particular as regards the proper identification of seeds, stating that they shall be true to name, etc. But it often happens that shipments of seeds which are purchased by seedsmen become more or less mixed as labels are lost in going through the custom house, and their exact identity is not always easy to determine.

Difficulties underlying Identification of Seeds.

The wide variation in the results of seed germination and purity has been previously touched upon in this article, and we now turn to a more detailed discussion of the difficulties which surround the analyst in the matter of the identification of some of the more common agricultural seeds, the horticultural or trade name of which varies from the true botanical name, especially in regard to the varieties. It is often found that a seed which has a certain botanical name is sold in the market under a distinctly different trade name; thus a great difference of opinion is found in a discussion of the seed from the legal point of view. Under a great many of our existing seed laws, therefore, a wide difference of viewpoint and application may be exercised without wilful misbranding by any one.

The following table shows this to a remarkable degree. It is concerned with the identification of certain agricultural seeds of common occurrence, and while the identification of the seeds may not be the work of the best analysts in the country, it is fairly representative.

Table showing the Relative Accuracy with which Certain Agricultural Seeds can be determined botanically.

Sample Number.	Horticultural Name.	Name given by Analyst.
1,	Medium clover.	Red clover.
2,	Kentucky blue grass.	Kentucky blue grass.
3,	Orchard grass.	Orchard grass.
4,	Red top fancy.	Probably red top.
5,	Swedish turnip.	Rape.
6,	Rye grass.	Rye grass.
7,	Canada blue grass.	Canada blue grass.
8,	Meadow fescue.	Meadow fescue.
9,	Fine Rhode Island bent.	Agrostis spp. (Probably neither true red top nor Rhode Island bent.)
10,	Cabbage.	Cauliflower.
11,	Witch grass.	Probably rye grass.
12,	Brown mustard.	Probably black mustard.
13,	4-rowed barley.	Barley.
14,	Creeping bent.	Red top.
15,	English rape.	Probably Brassica napus (rape?).
16,	Mammoth red clover.	Red clover.
17,	Wild mustard.	Black mustard.
18,	Spring rye.	Rye.
19,	Kohlrabi.	Rape.
20,	Winter wheat.	Winter wheat.
21,	6-rowed barley.	Barley.
22,	Cauliflower.	Cabbage.
23,	Flat turnip.	German rape.
24,	Oat grass.	Common hair grass (Deschampsia flexuosa).
25,	German rape.	Turnip.
26,	Spring wheat.	Wheat (Triticum sativum).
27,	2-rowed barley.	Barley.
28,	Winter rye.	Rye winter.

The seeds were not labeled and were simply presented for identification without any explanation of the purpose. It will be seen from a study of the table that while the greater number of the seeds are correct botanically, a much smaller number are correct according to the horticultural name and variety. Samples No. 1 and No. 16 are horticulturally "Medium Clover" and "Mammoth Red Clover," respectively, but the analyst called them simply "red clover." Both are right from their individual viewpoint, but legally, which is the proper designation? It is the same with the barleys; horticulturally, they are designated as two, four and six rowed, respectively, but the analyst has classed them as barley, simply, which is incorrect from the seedsman's standpoint, and also from the application of the seed laws in some States.

Aside from the error resulting from a cursory examination of seed by an analyst for purity, etc., it would be very difficult for one to identify the different varieties of plants from a simple examination of the seed alone, — for instance, the different varieties of cabbage, rape, wheat, etc., — as the macroscopic and microscopic characters of the different varieties are so nearly alike in many cases. Very often the only way in which a seed can be proved to be true to name is by growing the plant to maturity and getting the fruit or product which is used for identification purposes. This, of course, is out of the province of the seed inspector, and he cannot be held to an absolutely true identification of the variety, especially in the instances mentioned. Very often, also, it is necessary to have the plant for identification, as the seed structure may be quite misleading.

In the matter of the proper identification of seeds it might be stated, also, that in the case of mixtures of seeds like Canada blue grass and Kentucky blue grass, unless the analyst is very careful, the presence of one or the other may easily be overlooked. In one instance that we know of a sample of Kentucky blue grass, which contained a large amount of Canada blue grass, was analyzed by 23 different stations in this and other countries, and 12 out of the 27 stations did not report the presence of Canada blue grass. Thus it can be seen that great care should be exercised in the matter of purity tests, and only thoroughly qualified analysts should be intrusted with the work.

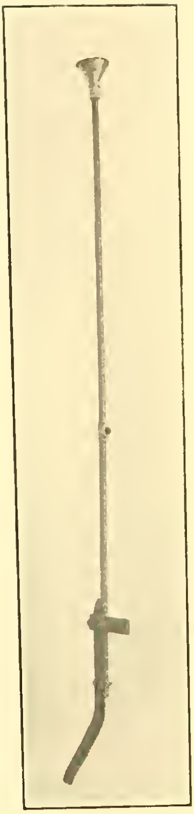

FIG. 1.—Showing device for planting white pine seed.

DEVICE FOR PLANTING WHITE PINE SEED.

G. E. STONE.

A few years ago the writer had occasion to plant some white pine seed in sod land, and the simple apparatus shown in Fig. 1 was devised for the purpose. It consists of a hollow iron tube about ⅝ of an inch in diameter, to the bottom of which is attached a bent piece of strap iron about 1¾ inches in width and thick enough to give the required rigidity. This is sharpened at one end like a chisel, and the iron handle extends to the bent part of the piece of iron. To the lower end of the hollow handle is attached a rubber tube which extends within a few inches of the end of the flat blade.

In using this device, which is designed to plant the seed easily and quickly, the chisel end or blade is thrust into the ground at such an angle that a slice of sod seldom more than ⅝ of an inch in thickness is raised. The planter is then brought to a vertical position and three or four seeds dropped into the funnel at the top. The seeds fall underneath the thin layer of sod, and then the instrument is taken out and the sod pushed back to cover the seed. This planter has been used to some extent in its original form by various persons, and no attempt has been made to improve upon it as yet. It operates easily, however, and does away with the stooping over required by the ordinary methods in use.

The general opinion among foresters is that it does not pay to plant white pine seed, and that much better results can be obtained from seedlings. It costs much less to plant seed, however, and it should be remembered that the great bulk of the white pine which has been growing in the State for centuries started from seed. It should also be pointed out that the New England States are unusually well adapted for the growing of white pine, and most of our waste land would soon be covered with this tree if left to itself. It may be true that it requires a great many seeds blown from a tree in a pasture to start one seedling, but when the seeds are planted the case is different.

The cost of planting seedlings at the present time appears to be prohibitive, and this view is taken by most of our lumbermen and farmers. Hon. J. J. Hammond of Northampton has tried both methods on his farm in Goshen, and is enthusiastic over the planting of seed.

The device shown in the illustration could be improved in some ways, and could perhaps be made lighter. It is a question whether it would be worth while to attach an automatic device for regulating the number of seed, as it is very easy to drop a few seeds from one's pocket into the funnel. Pine seed will frequently not germinate more than 30 per cent.; therefore it is desirable to plant several seeds in one spot.

CHESTNUT BLIGHT.

G. E. STONE.

This disease, already referred to in our previous reports, has been with us now for five or six years, and in some sections has become quite prevalent. It was first noticed in the vicinity of New York in 1905 by Dr. W. A. Murrill, since which time it has spread over considerable area. The writer has been observing the disease from the time it was first introduced, and has been able to watch its increase in various parts of the country. The fact that it has spread more rapidly and extensively southward than northward has led us to take an optimistic view of the continuation of its ravages in Massachusetts.

Along with the blight has been a deterioration of the chestnut tree which does not seem to be in any way associated with the blight fungus. While no attempt has been made to survey the State systematically, to learn the range of infection, our examinations of diseased material sent in to the experiment station the past few years have thrown considerable light on its distribution.

The first infections are naturally the worst, and are confined in a general way to our river valleys, — the Connecticut, Housatonic and Blackstone and their immediate neighborhoods, while the eastern central section of the State still remains comparatively free from the disease.

The chestnut blight, like the elm-leaf beetle infection, appears to be working up through the Connecticut valley in particular, and this is the worst infected region in the State. To one diseased tree found this year there will no doubt be seven or eight next year, and this is the ratio of increase each year.

The small, smooth bark trees are the ones most largely infected, the old and rough bark trees being least susceptible.

Two or three year old sprout growths easily fall a prey to the disease, more often near the base where the light is more or less excluded and where there is more moisture. In the case of old, rough bark trees the infection occurs first on the younger branches and twigs, but very few old trees are affected as compared with the younger trees in our locality. The unusual amount of deterioration and the dying out of the chestnut everywhere common, which is in no way associated with the blight, have led many to exaggerate the extent of infection from the fungus, many hundreds of trees having been pronounced infected when they were not. The real blight is surely a serious enough thing without exaggeration considering the melancholy fact that no practical and efficient remedy or even suggestion of one is in sight.

WEED EXTERMINATION.

G. E. STONE.

In recent years a great deal has been done along the lines of weed extermination, and many different methods have been experimented with and some of them adopted. There are several proprietary articles and mechanical devices on the market purporting to solve some of the phases of the weed question, but most of them are rather expensive when used on a large scale. When one needs only a small amount of weedicide, however, it is better to buy the easily procured proprietary article than to bother with the crude material, which is often hard to obtain.

Sulfate of iron has proved valuable in the west for the extermination of such tender plants as mustard and others when used as a spray in grain fields, and it can also be used for killing dandelions in lawns. It is inexpensive when bought in bulk, although the proprietary article, consisting of pulverized sulfate of iron mixed with nitrate of soda and sand and put out in expensive containers, is not so cheap. Arsenate of soda, which can be bought in bulk or as a commercial article, and similar compounds are also used as weed killers.

Of the several mechanical devices used for weed extermination, some are designed to pull up the weeds and others to kill them by injecting poisonous chemicals into the roots, while still others do the work by burning. Even electricity has been tried, but with rather unsatisfactory results, since considerable current is required to kill even small plants. Salt, copper sulfate, carbolic acid, nitrate of soda and many other materials have been used as weed killers, and undoubtedly in the future cheaper and more efficient methods will be found.

Arsenate of Soda.

Arsenical compounds appear to be the most poisonous to weeds. Of these, arsenate or arsenite of soda is usually employed, and is especially valuable for destroying weeds in dirt walks, roads, ditches and tennis courts and for killing poison ivy about trees, buildings, stone walls, etc. It is very poisonous to plants and lasting in its effects. One or two applications at the rate of 10 gallons of the solution per square rod (made up of 1 pound of the arsenate of soda to 5 or 10 gallons of water) will last for some years. This substance does not appear to leach out of the soil to any extent, while many others used as weed killers either volatilize quickly or leach out through the soil, producing only a temporary effect. Arsenate of soda can be used to advantage also in treating 4 or 5 inches of a lawn close to the foundations of buildings, to save clipping by hand the tall grass which cannot be reached with a lawn mower.

The most satisfactory way to apply arsenate of soda is by means of a sprinkler with an attachment to direct the spray (Fig. 1). With this device it is possible to treat walks up to the very edge without injuring the grass in the least. A single drop of arsenate of soda will injure any vegetation it touches, so care must be used in handling it; therefore this little attachment shown in Fig. 1 is valuable for directing the liquid. Arsenate of soda should not be used too freely near the feeding roots of trees, but we have never noticed any injury from treating walks near shrubbery or even within a few feet of large trees.

Weeds in Lawns.

To insure a heavy growth of grass and absence of weeds a lawn should have a good, deep foundation of rich soil, well supplied with organic matter and plant food. It is also important that the soil should possess the proper physical properties or texture in order to produce a good growth of grass, and it should have sufficient water-retaining capacity to enable the grass to endure drought. A soil of medium texture well provided with loam, with a water-retaining capacity of about 70 per cent., is much better than a coarse soil of less water-retaining capacity; for in seasons of drought the coarse soil will dry out very quickly and the grass will suffer, whereas the reverse is true of the fine soil. The weed proposition loses some of its importance if the lawn is well made, since a good growth of grass will crowd out the weeds. New lawns are more troubled

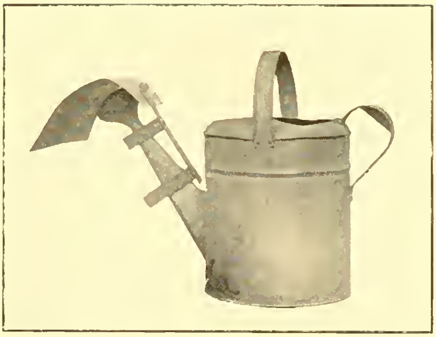

FIG. 1.—Showing watering-can with device for applying arsenate of soda.

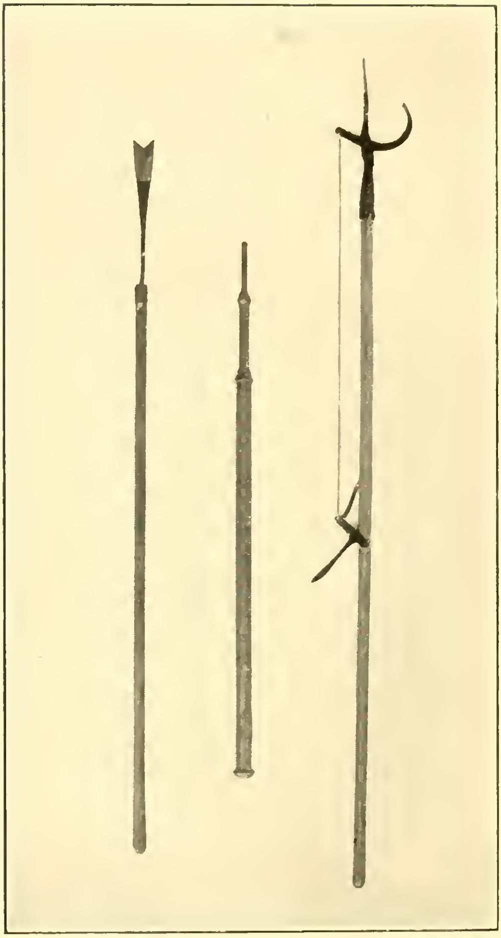

FIG. 2. — Showing different types of weed exterminators. Figure at the right, home-made device for cutting lawn weeds. Figure to the left, similar device. Figure in the center illustrates a device for injecting poisons into the roots of weeds.

with weeds on this account. One of the worst weeds affecting new lawns is crab grass (*Digitaria humifusa*), but it lasts only a year or two, as a rule. It is much more troublesome on dry lawns, where the catch of grass is poor. Frequent close cutting of the grass in the fall is a good preventive, since the seed is not allowed to mature. Two of the plantains, *P. lanceolata* and *P. major,* are troublesome in lawns, more especially where the grass is thin. Cutting plantain at different distances from the roots with a special device has not always proved satisfactory, and our observations have shown that when cut in this way a large percentage of the plants renew their growth (Fig. 2). This appears to be true, also, of the dandelion.

The following table shows the results of cutting plantain stems. The experiments were made by Mr. A. J. Sullivan, a student assistant.

TABLE I. — *Showing Results of cutting Plantain Stems* (*Plantago Major L*).

LOT.	Number of Plants used.	Method of cutting Stems.	RESULTS.	
			Growth.	No. Growth.
A, ...	25	Very close to roots.	17	8
B, ...	25	⅛ inch from roots.	16	9
C, ...	25	⅛ to ¼ inch from roots.	20	5
D, ...	25	¼ inch from roots.	15	10
E, ...	25	⅛ inch from roots.	20	5
Total, ...	125	– – –	88	37

After being cut the plants were set out in boxes in good soil and under favorable conditions for growth. They were planted slightly below the surface of the soil to prevent the death of the cut surface. The results do not show much difference as regards distance of cutting from the roots, although those plants cut near the roots show a weak and more tardy response. Of the total number of plants cut, 88 started to produce new foliage and 37 failed to respond.

The stems of plantain are, as a rule, only about ¾ or 1 inch in length, and if cut quite deep below the surface of the ground a considerable percentage could possibly be destroyed.

The effects of the prevailing winds on plantain seed are often shown in their distribution on lawns. In winter their seed spikes are often found protruding above the snow, and when the snow has a crust the seeds are easily carried long distances, and often land at certain points corresponding with the action of the wind.

Many other weeds, when cut below the surface, will not renew their growth. The device shown in Fig. 2 consists of an asparagus cutter inserted into a handle, and is a cheap, practical and easily used tool for cutting roots below the surface.

Frequent applications of fertilizer to lawns is of some service in exterminating weeds. For this reason we have devised a lawn fertilizer spreader,[1] consisting of a holder mounted on rubber-tired wheels, with an opening ¾ of an inch in width which can easily be opened or closed while operating the machine (Fig. 3). The spreader is provided with a revolving cylinder which keeps the fertilizer pulverized and in motion. This device was designed to improve upon the clumsier method of hand spreading, and it will spread the fertilizer so evenly and thoroughly that every root can be reached. With its use more fertilizer may be required to completely cover the lawn, but a great deal is gained by the thorough application and even distribution. It is not designed to spread coarse manure, but may be used with pulverized sheep and cow manure and commercial fertilizers.

Besides using pulverized sheep or cow manure in the spring or fall, wood ashes, nitrate of soda, sulfate or muriate of potash may be applied. We have found it well to fertilize in late summer when the grass is losing its vigor, which keeps it growing and in good condition up to the end of the season, and also helps greatly to crowd out undesirable fall weeds.

Weed Seeds in Sheep Manure.

Pulverized sheep and cow manure, while excellent for lawns on account of the large amount of organic matter which they contain, do, like other manures, possess a disadvantage in the undesirable weed seeds often found in them. Most of the pulverized manures come from the Chicago stock yards, and west-

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[1] In the design and construction of this spreader the writer is indebted to M. E. A. Thompson of Amherst, whose ingenuity and skill are highly appreciated.

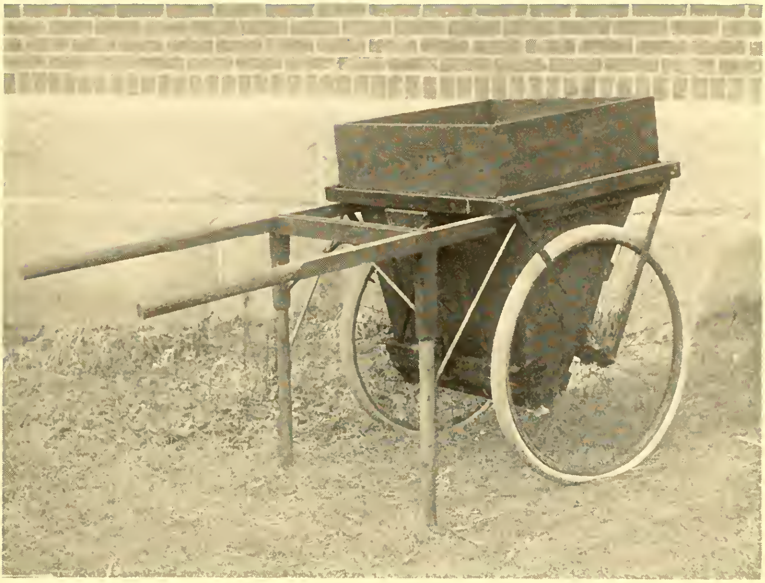

FIG. 3. — Showing fertilizer spreader for lawns.

ern seeds are likely to predominate in them. An analysis of pulverized sheep manure shows the following weed seeds in one pound: —

TABLE II. — *Showing Number and Kinds of Weed Seeds in One Pound of Pulverized Sheep Manure.*

KIND OF SEED.	Number of Seeds.
Ladies' thumb,	580
Tumble weed,	670
Sorrel,	390
Timothy,	1,000
Foxtail,	400
Panicum and other species,	820
Plantago lanceolata, etc.,	200
Total,	4,060

The figures given in this table show the great number of seeds in pulverized sheep manure, — 4,060 to 1 pound, which would be equivalent to 406,000 seeds in a 100-pound bag. But this table represents only one analysis, although taken from a typical sample on the market. Some of the seeds named are of little account, while others, like *Plantago lanceolata* and certain *Panicums*, often prove noxious. One lawn with which we have experimented, and to which sheep manure was applied freely, became badly contaminated with *Plantago lanceolata,* which had never been noticed in the lawn before and must have come in with the sheep manure. It was most abundant in the poorest part of the lawn. In another case where pulverized sheep manure was used plentifully a remarkable catch of a beautiful little lawn grass growing about 4 inches high and known as *Poa annua* was found. The seed of this grass cannot be had in the market, and yet it is one of the most desirable lawn grasses, thriving in the shade where other grasses will not. Whether the sheep manure contained the seed, or whether it merely furnished a suitable environment for its development, as does potash for clover, was not learned.

The large amount of organic matter contained in sheep manure makes it an excellent lawn fertilizer, although from the point of view of plant food contained it is more expensive than most chemical fertilizers. Still, we believe that no chemical fertilizer can take its place on lawns. The number of weed seeds it contains is its worst feature, but this might possibly be overcome by some system of sterilization.[1] The application of steam would have a tendency to increase the ammonification and would be a troublesome process, but if the weed seeds could be killed by an application of formaldehyde and potassium permanganate it would be a practical method. Fumigation with this substance will kill onion seed very quickly, but whether it would have the same effect on weed seeds we do not know.

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[1] Some brands of pulverized sheep manure are said to be sterilized.

"MOSAIC" AND ALLIED DISEASES, WITH ESPECIAL REFERENCE TO TOBACCO AND TOMATOES.

G. H. CHAPMAN.

This disease, or forms of it, has been known for several years, and various articles and papers have been prepared dealing with its description, causes, effects and methods of treatment; but the results obtained have been so varied that one hardly knows what to conclude. One authority states positively that the disease is contagious, another that it is infectious and still others that it is neither. It is our object in this paper to review in brief the results of other investigators and also the results of several years' work on our part devoted to the study of so-called mosaic disease and physiological troubles which we believe to be more or less closely allied to it.

This disease is commercially important to the layman only as it affects tobacco, and to a less extent greenhouse tomatoes (we have never found this disease produced on field-grown tomatoes except under artificial conditions of growth), which seem to be less susceptible than other plants of the Solaniaceæ. It is very important in some localities as regards tobacco, however, because a leaf attacked by it loses its elasticity, and after curing will not make a good wrapper for cigars. The results obtained and presented in this paper will deal simply with its causes, probable methods of control, etc., as regards the practical grower, but not with the physiology and chemistry of the disease from a technical viewpoint. We do not mean to imply that we have said the last word on the subject, but we have made an earnest endeavor to clear up as many points as possible regarding this peculiar disease.

We believe that several other diseases, such as peach "yellows," aster "yellows" and others, are more or less similar in character to the true "mosaic," but this paper will treat only of the "mosaic" of tobacco and tomato. Experimental data have been obtained to a certain extent on these allied diseases and will be presented in a future report.

Description of the Disease on Tobacco and Tomato.

The appearance of this disease has been described by many investigators, and nearly all have described it in a similar manner, but more particularly with reference to tobacco than to the tomato. The general characteristics of the disease are the same for both plants, but some differences are found in extreme cases in its appearance on the tomato, as will be noted from the following description: —

In the first stages of the disease the leaves of both plants present a mottled appearance, being divided into larger or smaller areas of dark and light green patches, with very regular outlines. At this point, however, no unequal swelling of the areas is noticeable, but as the disease progresses the darker portions grow more rapidly (growing normally), while the light green areas grow very slowly, and in this manner leaf distortion is brought about. In the tomato the light green areas become yellowish as the disease progresses, and in very badly affected plants become finally purplish-red in color. This coloration, however, is probably a secondary result of the disease, and is found principally on plants which are exposed to strong light, but does not occur always, as it has been found that sometimes, even in badly affected plants, the disease may reach its maximum intensity without showing any reddish coloration whatever.

The reddish appearance is noticeable only on the upper side of the leaf, and extends only through the palisade cells. A discussion of the cause of this coloration will not be taken up in this paper.

We have under no conditions ever noticed this coloration on tobacco, but occasionally in the field have seen the affected portions of leaves show brown, dead areas of tissue, a condition which may be analogous, but which we have been as yet unable to prove.

On badly diseased plants of both tobacco and tomato the leaves are much distorted and stiff, and often, especially in the case of the tomato, are very badly curled, never possessing the flexibility of healthy, normal leaves.

We have also found this disease on other plants, but have not been able in every case to obtain the same trouble by inoculating back to tobacco, and *vice versa.* A. F. Woods (1) reports this trouble as occurring on poke-weed (*Phytolacca decandra*), and U. Suzuki (2) reports a similar trouble on the mulberries of Japan caused by extreme cutting back. We have also been able to produce the disease by pruning and inoculation of plants of ragweed (*Ambrosia artemisifolia*), Jimson weed (*Datura Stramonium,* L.) and others, but we have not been able to observe it in all its characteristics on potatoes, even when severely pruned. It undoubtedly occurs on many other plants, but we should not confound it with the results obtained from overfeeding, as the appearance of these two troubles is under certain conditions almost identical.

Occurrence.

On the tomato we find that the disease occurs only on plants grown in the greenhouse, or, in other words, forced plants, and most often on such plants as are pruned, seldom making its appearance on plants which are left normal. We have never observed this trouble on field-grown tomatoes, and, so far as we are able to discover, no one has observed it on such plants, probably for the reason that, as a rule, such plants are not heavily pruned. We have not been able to obtain it by pruning mildly on normal field-grown tomatoes, and the reason for this is found in the fact that the plants get a normal growth and are not forced, even though they may get a temporary excess of food materials as a result of the pruning. Forced plants, of course, are more susceptible to diseases in general, as has been proved over and over again by many investigators.

The disease as it occurs on tomatoes has from our observations very little economic importance, as it does not, as a rule, lessen the fruiting capacity of the vine or distort the fruit badly. This observation has been made time and time again in greenhouses in this and neighboring States. Occasionally, however, we do find a crop which is a failure, or individual vines which are a loss, but this is due to a lack of proper pruning or other conditions which tend to intensify the trouble. Small, nubbly fruit results, of no commercial value, and a generally stunted condition of the vine is always observed.

The disease as it occurs on tobacco is of more importance from an economic point of view, as, from the figures obtained from the United States Department of Agriculture, the annual loss in the United States alone is over $1,000,000 per annum. The trouble may appear in all stages of growth on tobacco, from the seedling to the mature plant. A great many instances are on record of the seedlings being affected in the seed bed, and we have observed it frequently in the past few years on old beds which have been used repeatedly. As has been observed by other writers, it is only occasionally that the first two leaves are affected, but often the succeeding leaves come diseased. The cause of the affection in the seed bed will be discussed later in the paper. If diseased plants are transplanted to the field they do not recover, and the whole plant becomes affected and worthless commercially. The appearance of the diseased plants in the seed bed is not so characteristic as its appearance on mature plants, but, nevertheless, they can be easily distinguished from the healthy plants. There is at first no distortion, but rather a mottled appearance of light and dark green areas which persist and do not disappear during the day, in opposition to the mottling which is frequently observed when for any reason plants are subjected to abnormal night conditions. The leaves are also somewhat roughened, which is caused by the beginning of the unequal growth of the healthy and diseased areas. When these plants are transplanted to the field we get the characteristic appearance of the disease, although sometimes they may not be severely distorted. Leaves of a plant which are not affected will not become diseased, since the disease can only be transmitted through the dividing cells, as has been shown by several investigators and verified at this laboratory.

As to the cause of this trouble much has been written by various investigators, but, as some of the earlier theories have long been proved fallacious, no discussion of them is necessary at this time. Among the later theories may be mentioned that of Beijerinck (3), who was the first to prove that the disease was effective only through the dividing cells, and held the view that the disease was caused by a liquid or fluid contagium (a definite, distinct substance having characteristic properties). This theory has not been proved, however, and the causative agent or agents are not held to be necessarily a single specialized product.

In support of Beijerinck's theory it may be said that, upon crushing the leaves or rubbing them between the fingers and then successively touching the terminal bud of other plants in the field which are not affected with mosaic, in some cases mosaic will occur on the leaves, developing after the buds have been touched. This, however, we are inclined to think is more due to the fact that the tender buds have been touched with the fingers, causing some bruising or abrasion of their cellular substance rather than to any *specialized* contagion transmitted from the diseased plant. Where the juice of diseased plants was sprayed on the terminal bud, however, we were unable to transmit the disease except in very few cases. Experiments were conducted to determine the truth of this observation, and the method of doing this has been to rub a diseased leaf between the fingers, then to touch successively the terminal buds of a number of other plants unaffected with the mosaic with the hand which had been rubbed with the diseased leaf; then on another series of plants the hand was rubbed with a leaf which had no mosaic, and the plants successively touched, without touching any plants which were affected with the disease. In a great number of cases the disease appeared on the plants which were touched with the hand rubbed with the diseased tissue, while those touched with the hand which had been rubbed with a healthy leaf were nearly all normal, only a few developing the disease. This method of infection has been used by other investigators. The infection, however, we do not believe to be caused by a specialized virus, but rather by a combination of enzymes, which view has been held by A. F. Woods, and also proved by us at this laboratory.

The direct cause may be found in the presence of free hydrogen peroxide or some other residuary by-product of plant metabolism which has been allowed to remain unassimilated in the cells of the leaves through the excessive development and retardation of certain enzymes. We have shown conclusively in previous experiments that catalase in the diseased leaves was present in far less amounts than in healthy leaves, and as it has been found and proved by Loew (4) and other investigators, principally Jensen (5), that the chief function of catalase seems to be its power of destroying free hydrogen peroxide, breaking it up into water and oxygen, and this in so powerful a manner as to be observable in the presence of the least amount of catalase, and also as there was an excessive amount of other enzymes present, of which we will speak later, we are led to conclude from the observations and experiments carried on by us that the disease is not caused by a specialized virus. There is no doubt whatever that the disease is infectious, but it may be stated with equal certainty that the trouble is not contagious.

The disease being caused primarily by the excessive action of certain enzymes and a corresponding reduction of function of others, it is easily seen that any disruption of the normal metabolism of a plant will tend to produce the disease, and also A. F. Woods has pointed out that the excess enzymes in decaying roots, etc., are able to start up these changes and so produce the disease. The more technical experiments which we have carried on supporting these views will be given in another paper.

The secondary causes are by far the most important to the grower, as in many instances he can by careful attention remove or control the conditions, especially in the seed bed. Among these causes may be mentioned too high a temperature in the seed bed, accompanied by excessive moisture or too little. Soil moisture conditions alone do not seem to be of any effect as a causative agent. This has been shown by various investigators, and was not particularly studied by us. Where the trouble shows in the seed bed and is not brought on by too high a temperature it may be due to the following causes, as has been deduced from our observations and experiments: —

The seed bed may have been used for several successive years without change or rest, and thus the soil has become inoculated with the causative enzymes; or roots and diseased plants may have been left inadvertently in the soil, and on their decay the enzymes persisted. This condition may be remedied by thorough sterilization with steam, or by using beds which have not grown tobacco before, or by letting the beds grow to grass for a year or two before using again, two years being better than one. The activity of the noxious enzymes appears to lessen during this time, and finally ceases. Although we have not verified the following in our experiments, it is stated that too high a nitrogenous soil content will sometimes cause the disease in the seed bed.

Improper sterilization of the seed bed will sometimes increase the disease for the following reasons: the soil which is improperly steam-treated renders certain of the plant foods more available, and yet does not render the enzymes inactive, and thus for a time accelerates plant growth by excessive forcing, rendering the plant more liable to attacks of disease during the period of forcing. This condition has been observed occasionally by us and can be explained on no other grounds. As a result of the improper sterilization the temperature of the soil is not raised sufficiently to kill the enzymes, and therefore they remain active in the soil. Thorough sterilization will kill enzymes, or at least two sterilizations will kill them, thus getting rid of the residuary zymogen or revivified enzyme.

In the Field.

As has been pointed out by other investigators, there are many ways of contracting the disease in the field, but it has been definitely proved that excess or lack of mineral fertilizer alone will not cause the trouble. This idea was first advanced by Meyers (6) and Beijerinck (7) who showed that the disease could not be brought on by excessive use of mineral fertilizers, although a leaf distortion due to overfeeding is quite often observed. These results were verified in our work in the laboratory and field.

One of the chief causes of the production of the disease is, without doubt, — as has been pointed out by Woods (8), Sturgis (9) and others, — improper methods or carelessness in transplanting. We are inclined to think from our observations that fully 80 per cent. of the diseased plants, particularly in this locality, may be traced to improper transplanting. It has been shown that when the roots are lacerated in any way the trouble may gain a foothold, as the metabolic or life processes are thus deranged, and a condition favorable to the disease is introduced. We have found that when the roots are broken or torn to any great extent in removing the plants from the seed bed they are often liable to become diseased. With regard to this point we may quote from a Connecticut station report: —

> In this connection Mr. Barnes of Hatfield related the following: "Young plants were taken from the same seed bed by two different farmers, and although the soil of the fields was the same, one farmer had many mosaic plants in his field and the other had almost none. Inquiry revealed the fact that one farmer took the plants from the seed bed when it was quite dry, the other when it was well moistened. In taking the plants from a dry bed one cannot help lacerating the roots, while from a well-moistened bed the roots may be drawn in an almost intact condition. Lacerated roots do not generally develop to such a vigorous state as is required by a quickly growing tobacco plant."

We made experiments in regard to this point and the above observation was verified. In the majority of cases of the dry plants a large percentage developed the disease. The remedy in this case suggests itself, that is, the seed bed should be in moist condition when the plants are removed, but not so wet as to have any adhering ball of earth on the roots; but this condition is rarely found, as very little soil remains on the roots when they are taken from the seed bed.

After the disease appears in the field it is practically impossible to control it, but it does not usually make its appearance on plants not affected in the first few weeks of growth. Mild cases of this trouble sometimes appear when the flower bud is left on, as has been shown by A. F. Woods, and the mottled appearance often shows on plants which have been topped on the subsequent growth, *i.e.*, the suckers. Soils of a compact, clayey character also sometimes induce the disease indirectly by requiring constant close cultivation to prevent packing, and as a result the roots are often lacerated, uneven growth resulting, thus bringing about abnormal changes in the processes of plant metabolism.

It is stated that broad-leaf tobacco is more liable to this disease than Havana, but we have been unable to verify this statement locally.

Shade-grown or tent-grown tobacco is said to be less liable to the disease than that grown without shade. This has been our experience and is borne out by the statements of practical growers who have grown both kinds. The conditions governing growth under shade are of course more uniform than in the field, and a more regular and slower development of the plant is brought about.

SEED.

Various investigators have pointed out that the disease is not transmitted through the seed, as it has been shown repeatedly that seed from mosaic plants will produce healthy plants and *vice versa;* also that there is no difference in the seed produced by cross pollination as regards susceptibility to the disease, and this has been so repeatedly proved as to need no verification. It is a fact, however, that the heavy seed of tobacco will produce larger, better and more uniform plants through careful selection, and as this laboratory has made a specialty of separating the seed for the growers for the last few years, observations on the prevalence of the mosaic were made among the fields each year, and it was found that growers who were having their seed separated each year had less and less trouble with mosaic, due somewhat to the selection of a more vigorous seed. Only the heavy seed was planted, and only the seed of the best plants saved; thus a process of seed selection was practiced and naturally an improvement in the quality of the plants was found. The seed is separated by a blast of air, and a detailed account of the method will be found in one of the bulletins (10) of this station. In experiments carried on at the laboratory it was found that the plants from heavy seed were less liable to the trouble than the light, discarded seed; these latter did not produce strong, healthy plants, but were weak, and thus more liable to the trouble when favorable conditions were present. It must be understood, however, that there is nothing inherent in the seed itself which would cause the trouble; it is simply a matter of getting strong, viable seed to produce vigorous plants.

Review.

A more or less popular account has been given in the preceding pages of the cause, appearance and general characteristics of this interesting disease, and a later report will take up the more technical part of the work, when most of the experiments carried on will be described. At this time a brief review of the preceding pages will be given, in order to summarize the facts presented.

1. "Mosaic," "Brindle," "Calico" or "Mottle top" of tobacco is a physiological disease purely and has no fungous or bacterial origin. It is caused by the excessive activity of the oxidase and peroxidase enzymes in the plant and the partial loss of function of catalase, another enzyme, which carries off some of the residual products of the others mentioned. It is not due to one enzyme alone nor to any specialized virus.

2. It is infectious but not contagious. Care should be exercised not to touch the terminal bud of healthy plants with anything which has come in contact with diseased plants.

3. It does not occur in the seed beds when new soil is used nor in properly sterilized seed beds.

4. Improper sterilization of seed beds or old beds tends to intensify the disease if present.

5. The temperature of the beds should not be allowed to run too high for any length of time. It is better to run the bed rather cool than too hot.

6. Where a seed bed is infected it may be grown to grass for a year or two and then used again for tobacco.

7. An excess of mineral fertilizers in the field does not cause the trouble nor intensify the disease.

8. Care should be exercised when the stems are used for fertilizer that the stems of mosaic plants are not used, as they may prove a source of infection.

9. Excessively clayey soils should be avoided, especially in growing Havana tobacco.

10. Once the disease appears on a plant all subsequent growth

will be mosaic to a greater or less extent. A badly affected plant is worthless.

11. Shade-grown tobacco is less liable to the disease than ordinary field-grown, as a more uniform growth is obtained.

12. Great care should be used to remove the plants from the seed bed when the soil is moist, as thereby the roots are less liable to injury and few are broken. They should not be allowed to dry out.

13. Thorough and timely cultivation will do a great deal towards the prevention of this disease.

14. Careful seed selection and separation will also help the grower by giving him stronger and more vigorous plants.

In conclusion it may be said that if care is used and sufficient attention paid to all stages of the growth from the time the seed is planted until the plants are mature, and the results studied and acted on rationally, the amount of mosaic will be greatly lessened, and, in fact, practically eliminated from the field. It should be understood, however, that under adverse conditions, such as unsuitable soil, etc., one cannot expect to eradicate this trouble.

In a future paper will be taken up the more detailed and technical work performed by us in the study of this trouble, also additional notes on similar diseases of other economic plants.

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THE VALUE OF OATS FOR MILK PRODUCTION.

J. B. LINDSEY.

Oats are held in high esteem as a food for all classes of farm animals, and particularly for horses. They are also regarded as a valuable food for milk production, although their relative cost, especially in the east, has prevented their general use for this purpose. For example, the average wholesale price for a ton of oats in 1910 was $29.51, and for the first eight months of 1911 it was $26.99, as against $26.39 and $23.88 for corn meal.

The fact that oats are so highly regarded for the production of milk led the station to conduct three demonstration experiments with dairy cows, comparing ground oats with a like amount of corn meal.

THE COMPOSITION OF OATS.

	Oats fed.	Average American Analyses.[1]	Average Foreign Analyses.[2]	Corn Meal fed.	Average Massachusetts Analyses.[3]
Water,	10.80	10.40	13.30	14.50	11.00
Ash,	3.25	3.20	3.10	.86	1.30
Protein,	12.15	11.40	10.30	7.93	9.80
Fat,	4.41	4.80	4.80	5.74	3.90
Fiber,	8.91	10.80	10.30	.81	2.00
Extract matter,	60.45	59.40	58.20	70.16	72.00
Total,	100.00	100.00	100.00	100.00	100.00

[1] Henry, 1910. [2] Kellner, 1909. [3] Lindsey's Compilation, 1910.

Oats vary in composition rather more than some other cereals. The larger the per cent. of hulls, the lower the percentages of protein and fat. Oats that are imperfectly developed are likely to have relatively more protein and less starchy matter than those that have been well formed. The percentage of hulls varies between 20 and 35, with a probable average of 26. It was held formerly that they contained an alkaloid *avenin* which accounted for their peculiar effect in imparting spirit to horses, but more recent investigations have failed to identify this product. E. Schulze identified an alkaloid Trigonellum in the oat, but the amount found was so small as to be without influence as a stimulant.

The corn meal fed in the present experiment was the usual material now offered in the general markets. It evidently was not ground corn kernels, but a sifted product resulting from the manufacture of cracked corn. The analysis of corn meal given for comparison represented the average of 119 samples of ground corn kernels. It is higher in protein and fiber and lower in fat than the sifted product.

Oats differ from corn in having noticeably more ash, rather more protein and decidedly more fiber.

The Digestibility of Oats.

The coefficients of digestibility were not determined in the particular sample fed. Here follow the average coefficients obtained for American and German oats: —

	American.[1]	Foreign.[2]	Corn Meal for Comparison.
Dry matter,	70	70	83
Ash,	25	–	67
Protein,	77	76	–
Fiber,	31	26	–
Extract matter,	77	76	92
Fat,	89	80	90

[1] Lindsey. [2] Kellner.

Applying the above coefficients to the average composition of American and foreign oats, and to the average analysis for corn meal, we have the following amounts of digestible matter in 100 pounds: —

	American Oats.	Foreign Oats.	American Corn Meal.
Protein,	8.78	7.83	6.57
Fiber,	3.35	2 68	-
Fat,	4.27	3.84	3.51
Extract matter,	45.74	44.23	66 24
Total,	62.14	58.58	76.32

One hundred pounds of corn contains, therefore, some 16 pounds, or 27 per cent., more digestible material than a like amount of oats.

Kellner placed the net energy value of corn at 81.5 and of oats at 59.7, or as 100 is to 73.2 (starch equivalents). One would, therefore, assume that for the ordinary purposes of nutrition oats were substantially one-fourth less valuable than corn. This does not take into account the favorable mechanical or special energy effects of oats. The nutritive inferiority of oats is due to the large percentage of indigestible hull. The oat kernel free from hull is easily and highly digestible.

Feeding Experiments for Milk Production.

Three feeding experiments with four cows each were made at this Station. Each animal received a basal ration of hay and bran to which was added an average of 4.5 pounds of corn or oats. A complete summary of the details of the experiment are given in Part I. of our report for 1912.

It may be said in general that the oat ration gave substantially as good results (*a*) on the weight of the animal, (*b*) on the amount of milk and butter-fat produced, and (*c*) on the composition of the milk.

On the basis of such experiments one would conclude that oats were as desirable as corn for this purpose, which would be contrary to the teachings of analysis and digestion tests. It is believed, however, that the experiments were incorrectly made in that too much of the basal ration was fed, so that when the oats or corn were added the total nutrients were fully up to or in excess of the requirements of the animal. Therefore, the particular effect of the corn or oats was not brought out.

In experiments of this sort care must be taken to keep the basal ration low, so that when the food to be tested is added the total ration shall still be below the animal's average requirement.

The food cost of the milk produced in case of the three experiments was 3.5 per cent. higher for the oat than for the corn ration. If somewhat less of the basal ration had been fed, it is thought that a still greater difference would have been brought out.

In general, it is believed that while oats are a valuable food, it is not economical to feed them for milk production in Massachusetts, and that they are inferior in nutritive value to corn.

SOME PRACTICAL RESULTS OF FEEDING EXPERIMENTS.

J. B. LINDSEY.

Feeding Effect of Raw Potatoes.

In the spring of 1910 potatoes were plentiful and cheap, and some farmers fed them to their dairy animals rather than throw them onto the field. The complaint came to the station that potatoes thus fed caused a noticeable shrinkage in the fat of the milk, and that the cows dried off rapidly. In order to note the validity of such statements three grade Jersey cows were selected that had been in milk since the preceding autumn. They were each given a basal ration of hay, bran and gluten feed, and after an interval of five days potatoes were gradually added and the amount of hay somewhat reduced as the amount of potatoes fed was increased.

Daily Ration in Pounds.

	Betty.				Daisy.				Red III.			
	Hay.	Bran.	Gluten Feed.	Potatoes.	Hay.	Bran.	Gluten Feed.	Potatoes.	Hay.	Bran.	Gluten Feed.	Potatoes.
May 18-22,	18	3	4	–	18	3	4	–	18	3	4	–
May 23-24,	18	3	4	10	18	3	4	10	18	3	4	10
May 25-29,	18	3	4	15	18	3	4	15	18	3	4	15
May 30-June 2,	16	3	4	20	14	3	4	20	16	3	4	20
June 3-5,	16	3	4	25	14	3	4	25	16	3	4	25
June 6-8,	16	3	4	30	14	3	4	30	16	3	4	30
June 9-10,	16	3	4	35	14	3	4	35	16	3	4	35
June 11-15,	16	3	4	40	14	3	4	40	16	3	4	40
June 16-21,	16	3	4	50	14	3	4	50	12	3	4	50

The cows consumed the cut potatoes readily and without any disturbance until they received 50 pounds daily. It was then noted that a little digestive disturbance began to manifest itself, and, the supply of potatoes being limited, the trial was broken off as soon as possible. The potatoes, especially during the latter days of the trial, were of inferior quality and watery. If the amount of hay fed daily had been further reduced, and had the supply of potatoes held out and been of better quality, it is possible that the animals would have consumed more without trouble.

Average Daily Yields of Milk (Pounds).

	Betty.	Daisy.	Red III.
May 18–22,	18.5	18.2	19.2
May 23–June 2,	20.1	20.3	21.4
June 3–10,	19.0	18.9	21.2
June 11–21,	18.4	20.3	22.0

It is evident that the addition of the potatoes in two out of three cases not only checked the natural shrinkage but actually increased the flow.

Composition of Milk.

DATES.	BETTY.			DAISY.			RED III.		
	Total Solids.	Fat.	Solids not Fat.	Total Solids.	Fat.	Solids not Fat.	Total Solids.	Fat.	Solids not Fat.
May 23–26,	13.83	5.10	8.73	14.27	5.75	8.52	15.04	5.35	9.69
June 6–8,	14.71	5.08	9.63	15.68	5.88	9.80	14.36	5.35	9.01
June 9–12,	14.91	5.20	9.71	15.94	6.13	9.81	14.43	5.40	9.03
June 16–19,	14.93	5.35	9.58	15.75	5.90	9.85	14.42	5.35	9.07
June 23–26,	15.43	5.65	9.78	15.69	5.88	9.81	14.59	5.28	9.31

In two out of three cases one notes an increase in the milk fat, due, presumably, to an advanced stage of lactation. In case of Red III. the milk fat remained constant throughout the entire trial. It would appear that the potatoes increased the percentage of solids not fat in the milk produced by Betty and Daisy. The results in case of Red III. are just the opposite, the percentage of solids not fat showing a noticeable decrease. One does not feel justified, therefore, in drawing any positive conclusions other than to state that the chemical composition of the milk was not in any way adversely affected. Unfortunately, observations upon the flavor of the milk were not made.

Conclusions and Observations.

1. When potatoes are cut and fed in amounts up to 25 pounds per head daily, they in no way affect the health of the animal or the yield or quality of the milk.

2. The feeding should begin gradually, and when the supply begins to get low the amount should also be decreased gradually. They should always be fed with reasonable amounts of grain and hay; one of the concentrates should be fairly rich in fat. If fed in too large amounts at first, or in excessive amounts, or without the necessary amounts of other feedstuffs, they are likely to cause diarrhœa, colic and bloating. Such conditions naturally disturb the entire equilibrium of the animal and result in loss of flesh, decreased milk yield and a generally debilitated condition. They should not be fed with malt sprouts or molasses, and with only limited amounts of silage.

Results of Foreign Observations.

Kellner[1] writes concerning the German experience in feeding raw potatoes, from which the following is a résumé: —

An opinion has been handed down from earlier times, and still more or less prevails, that raw potatoes cause inflammation of the stomach and intestines, resulting frequently in digestive disturbances such as diarrhœa, bloating, colic, and, in case of young animals, lameness. Such disturbances he attributes to the fact that exceptionally large amounts of potatoes were fed — up to 100 pounds or more daily — without the addition of sufficient amounts of other feedstuffs. The fact must not be lost sight of that different animals are differently affected by raw potatoes. The most sensitive is the horse, then follows the sheep, while the steer and cow are able to consume them with less trouble.

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[1] Die Ernährung d. Landw. Nützthiere, fünfte Auflage, pp. 327–329.

Fattening steers can take as high as 60 pounds of raw potatoes daily per 1,000 pounds of live weight. Small amounts should be given at first, followed by a gradual increase, together with 2 to 3 pounds of linseed meal or other feedstuffs fairly rich in fat, in addition to some other grain and hay or straw. If it is desired to cease feeding the potatoes this also should be done gradually. Potatoes may also be mixed and fed with other roots, especially mangolds.

Working oxen should not be given more than 20 pounds daily per 1,000 pounds of live weight, preferably mixed with cut hay or straw, in addition to their grain ration.

Milch cows should not, as a rule, receive over 25 pounds daily per 1,000 pounds live weight, together with some concentrate rich in oil. Kellner states that larger amounts are likely to produce a thinner milk possessing an unpleasant taste, the latter lasting for some time after the removal of the potatoes. Churning is likely to be long delayed when milk is used from cows fed with large amounts of potatoes.

Dry cows to be fattened, on the other hand, can be given as high as 40 pounds of potatoes daily, in addition to the feedstuffs above named.

It is not advisable to feed potatoes to *yearlings* and *heifers with first calf*, although from 10 to 15 pounds daily may be given *steers* the second year.

Sheep may be fed with 2 to 3 pounds daily per 100 pounds live weight.

Horses that are obliged to work hard and to move fast should not receive over 2 to 3 pounds of potatoes daily per head, although slow-working farm horses and three to four year old colts in foal may take as high as 12 pounds daily without trouble, in place of one-third of their grain ration. One must use good judgment and be very careful in feeding potatoes to horses, otherwise troubles such as diarrhœa and colic are very likely to result. In all cases where potatoes are fed it is important that they be of good quality, that they have not sprouted, and that they be cut and fed mixed with an equal amount of cut hay or straw and some salt.

Molasses for Farm Stock.

Residuum molasses from the sugar beet factories is largely used in Europe as a food for farm stock. It is fed either diluted with water as a drink or mixed by the feeder with a variety of substances to absorb it, such as finely cut hay and straw, brewers' dried grains, malt sprouts, wheat bran, cocoanut cake, dried beet and potato residues.

In New England cane molasses is brought in tank steamers from Porto Rico, and the grades unsuited for human consumption are freely offered at about 16 cents a gallon of 12 pounds, in barrel lots. Beet molasses is also sold, usually mixed with beet pulp, or as a component of proprietary mixtures.

Composition of Molasses.

The composition of cane molasses used as a cattle food is substantially as follows: —

	Per Cent.
Water,	24–28
Ash,	6–7
Crude protein,	2–3
Sugars (cane, dextrose and fruit),	55–58
Gummy or uncrystallized carbohydrates,	7–10

Molasses, therefore, consists of about one-fourth water and the larger part of the balance of sugars and allied substances. The crude protein is a negligible quantity, while fiber and fat are not present.

Beet molasses contains more crude protein than cane molasses, but it is in a form that renders it of little value as a flesh former.

Molasses has the same type of composition as corn meal, both being low in protein and very high in carbohydrates. The dry material of molasses differs chemically from corn meal in containing even less protein with an inferior nutritive value, more ash, and in having its carbohydrates in the form of sugars rather than starch.

Digestibility of Molasses.

It can be assumed with safety that molasses, being soluble in water, is easily digested and assimilated when fed in reasonable amounts. If fed in excess it is likely to affect adversely the heart and kidneys and to appear undigested in the urine.

Effect of Molasses on Digestibility.

As a result of numerous experiments it may be stated (*a*) that while molasses is completely digested, it does not improve the digestibility of the feedstuffs with which it is fed, but actually causes them to be less digestible (the average being 8 per cent.), and (*b*) that the addition of molasses to a ration slightly lessens the digestibility of the *entire mixture.* Only when 20 per cent. or more of molasses is added to a ration is the digestibility of the mixture slightly increased above the digestibility of the same ration fed without molasses. It is not advisable, as a rule, to feed a ration containing over 15 per cent. of molasses, so that under ordinary feeding conditions it may be stated that a total ration containing that amount of molasses would not have a higher digestibility than if fed without it, for the reason that the complete digestibility of the molasses itself is offset by the digestion depression which it exerts on the other feedstuffs.

Relative Value and Use of Molasses.

It must not be understood that because molasses lessens the digestibility of the other feedstuffs, or does not improve the digestibility of the mixture of which it is a component, that it has no feeding value. In fact, 2,000 pounds of molasses have substantially three-fourths of the nutritive value of corn meal, and if corn meal retails at $30 a ton, from the standpoint of nutrition, one can afford to pay $22.50 for a ton of molasses. Aside from its nutritive effect it possesses other desirable qualities to which allusion will presently be made.

Molasses for Dairy Animals. — Three to 5 pounds of molasses may be fed to cows daily in place of a like amount of corn meal, either in water as a drink or partly diluted with water and sprinkled over the hay or cut corn stover, or mixed with the protein concentrates. The writer, however, does not see any advantage to be gained by northern farmers from the use of molasses as a food for dairy stock in place of corn meal and similar carbohydrates. As an appetizer for cows out of condition and for facilitating the disposal of unpalatable and inferior roughage and grain, 2 to 3 pounds of molasses daily undoubtedly would prove helpful and economical.

For fattening Cattle. — Some 3 pounds daily of molasses may be fed advantageously, especially during the finishing process when the appetite is likely to prove fickle. The object at such a time should be to make the food especially palatable and thus induce a maximum consumption, and also to secure a bright, sleek appearance.

For Horses. — French and German investigators have studied and recommended the use of moderate amounts of molasses for horses. It is recommended as a condiment to be mixed with otherwise unpalatable foods, for its influence in improving the appetite and digestion of horses out of condition, and likewise for its favorable effect in case of colic. The writer of this article is not inclined to recommend the indiscriminate use of molasses in place of cereals and their by-products. As an appetizer and tonic for horses out of condition, as a colic preventive, and for improving the palatability of rations, 2 to 3 pounds daily undoubtedly will prove productive of satisfactory results. To facilitate the mixing with grains or roughage it is best to warm the molasses and then add a little warm water to dilute it.

For Pigs. — Favorable reports are made in the German literature relative to the use of molasses for pigs. At this college satisfactory results were secured at one time by stirring 50 pounds of low-grade flour into a barrel full of water, steaming the mixture for an hour or more and then adding a gallon of molasses. The writer, as a rule, sees no particular advantage, under ordinary conditions, for the northern farmer to employ molasses in pig feeding other than as an appetizer.

Molasses Feeds.

Molasses feeds usually consist of cereal grains or their by-products, such as oat clippings, oat and barley hulls, ground grain screenings, flax shives, ground alfalfa hay, one or more protein concentrates (usually cottonseed meal or gluten feed) and one-fourth to one-third molasses. The molasses is used for the threefold purpose of disguising the inferior feedstuffs, for improving the palatability of the mixture, and as a direct source of nutrition. The grain hulls, screenings, and the flax shives are used because they are relatively cheap, and also to serve as an absorbent for the molasses. The cereals themselves, at times, are of an inferior character, being imperfectly developed or moldy. The cottonseed meal and gluten feed are used to increase the protein content of the feed. Flax shives consist of the ground stalks and pods of the flax plant, and have a decidedly inferior feeding value. The better class of grain screenings possess considerable nutritive value. A number of years since, the writer studied the nutritive value of molasses feeds and found them to be moderately digestible (69 per cent., as against 62 for wheat bran, 79 for cottonseed meal and 88 for gluten feed and corn meal). During the last few years it is believed that the general character of these feeds has somewhat improved, in that the grain screenings have been ground, the protein content of some of them materially increased, and the fiber percentage lessened, all of which would tend to increase their digestibility. One notes at present, extremes of from 16 to 25 per cent. of protein and from 8 to 16 per cent. of fiber. A molasses feed that contains 18 per cent. of protein, and not over 9 per cent. of fiber, is worthy of consideration by feeders, providing it can be bought at a reasonable price. The tendency has been for the manufacturers to give them attractive names, make exaggerated claims for them and to sell them at prices in excess of their value. It is believed that local dealers secured a greater margin of profit on such mixtures than on staple feed articles.

It is not intended to discourage the utilization of low-grade by-products; when, however, they are disguised and sold at substantially the same prices as high-grade feeds, attention should be sharply called to the fact.

This autumn (1912) molasses dairy feeds retailed at from $27 to $34, and the horse feeds at from $34 to $40 a ton. It is believed that the average feeder can do better by purchasing staple grains and standard by-products and mixing his own ration. Advice concerning special brands cannot be given in this article. The feeder must study the guarantees and cost of the feed mixtures and use his best judgment, or seek the advice of the experiment station.

The Food Value of Plain and Molasses Beet Pulp.

A few years ago [1] the writer published a brief review of the value of beet residues for farm stock. Since this publication two experiments have been made at this station, comparing both the plain and molasses pulp (dried) with corn meal for milk production.

Beet pulp is the residue from the manufacture of sugar from sugar beets. The dried plain pulp is coarse and of a gray color. Molasses beet pulp is the pressed plain pulp mixed with the residuum beet molasses and dried. Another method of making the molasses pulp is to mix a definite amount of molasses with the dried pulp. It is understood that but little molasses pulp is now being made.

Composition of the Beet Pulp.

	Plain Pulp.	Molasses Pulp.	Corn Meal[2] for Comparison.	
Water,	9.08	8.48	14.99	15.60
Ash,	3.02	6.93	.86	.85
Protein,	8.90	11.16	7.88	7.82
Fiber,	18.76	10.16	.81	.80
Extract matter,	60.59	62.76	69.76	69.27
Fat,	.65	.51	5.70	5.66
Total,	100.00	100.00	100.00	100.00

It will be noted that the plain pulp contained about 9 per cent. of water, a relatively large amount of fiber, and practically no fat. The molasses pulp contained considerably more ash, due to the large amount of mineral matter in the molasses. The fiber content was considerably less than that of the plain pulp, due to the replacing of the pulp by the molasses which was without fiber. The amount of molasses added to the pulp appears to vary more or less in different samples.

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[1] Twenty-second report of this station, Part II., pp. 21–27.

[2] Samples used in experiment.

Both the plain and the molasses pulp are carbohydrate feeds similar to corn meal, being relatively low in protein and high in carbohydrates.

Pounds of Digestible Matter in a Ton.

	Protein.	Fiber.	Extract Matter.	Fat.	Totals.
Plain pulp,	92.56	311.42	1,005.79	–	1,409.77
Molasses pulp,	140.62	162.56	1,129.68	–	1,432.86
Corn meal for comparison,	105.59	–	1,283.58	101.88	1,491.05

The above figures show that a ton of the corn meal with substantially 15 per cent. of water contains about 5 per cent. more digestible organic nutrients than a ton of the dried beet pulp having 9 per cent. of water. One would not, therefore, expect to note much difference in the effect of these several feeds when used as a component of grain rations intended for milk production.

Practical Feeding Trials.

Six cows were fed on a basal ration of hay, bran and cottonseed meal. In addition, three of the cows averaged 4.3 pounds of dried plain or molasses beet pulp, while the other three were receiving a like amount of corn meal. After a lapse of five weeks the conditions were reversed. The results may be briefly stated as follows: —

Milk Yields (Pounds).

Character of Ration.	Total Milk.	Daily, per Cow.	Total Fat.	Butter Equivalent.
Corn meal,	3,941.3	18.8	215.3	251 1
Plain beet pulp,	4,017.1	19 1	216.5	252 6
Corn meal,	4,184.0	19.9	233.4	272.3
Molasses pulp,	4,054.0	19.3	220 6	257.3

In the first trial the corn meal ration produced about 2 per cent. less milk than the plain pulp ration, and in the second trial the corn meal ration caused an increase of some 3 per cent. of milk over the molasses pulp ration. These results are evidently within the limit of a reasonable experimental error, and one can conclude that the corn meal and beet pulp as components of a ration had about the same effect.

If the pulp can be purchased at a cheaper price per ton than the corn, it would prove a little more economical for dairy animals. If fed in an amount exceeding 3 pounds per day, it should be moistened with two to three times its weight of water.

The Place of Dried Beet Residues in Farm Economy.

Farmers who are in position to produce their own feed cannot afford, as a rule, to purchase starchy feedstuffs; they should be produced upon the farm in the form of corn, oats and barley. For milk production it is much more desirable to purchase materials rich in protein, such as cottonseed and linseed meals, dried distillers' and brewers' grains, gluten feed, malt sprouts, fine middlings and even bran. These feedstuffs are not only very helpful in milk production, but likewise supply large amounts of nitrogen in the resulting manure. When the supply of home-grown corn is exhausted or limited, beet residues may be substituted for fattening stock and as one-third of the grain ration for dairy purposes. Milk producers who purchase all of their grain will find the dried pulp a satisfactory component (one-third to one-half) of the daily grain ration. It can also be fed as a partial substitute for roughage in amounts of from 8 to 10 pounds of dry pulp daily. It should be mixed with two to three times its weight of water.

EFFECT OF FROST ON CORN.

J. B. LINDSEY.

So far as known, accurate data on this subject are not available. On Sept. 1, 1911, a severe frost occurred in New England, and most of the corn was severely frosted. At the experiment station the frosted corn was allowed to stand uncut for some two weeks, at which time samples of the different varieties were brought to the laboratory for examination. The ordinary analysis revealed little new, excepting that the fiber percentage seemed to be larger than is usually the case. It is doubtful if a more thorough chemical inquiry would give any definite information, for the reason that so many factors enter into the problem, such as variety, stage of growth and time of frosting. In order to get the necessary data, the following conditions would be necessary: (*a*) samples of corn secured within a day or two before frosting; (*b*) samples immediately after frosting; (*c*) if frosting occurs at this station between September 1 and 5, samples also to be secured of both frosted and unfrosted corn some two to three weeks after frosting, time of cutting to be the same in each case. By such a method one would be able to get comparative data. The mere taking of a sample after frosting is not likely to prove helpful if unfrosted samples at a similar stage of growth were not available for comparison.

WHAT PROBABLY OCCURS.

It seems probable that something like the following happens when corn is badly frosted: —

1. The cells of the plant burst, discharging the cell contents, and further growth ceases. This first evidently affects the leaves, husks and upper part of the stalk. It is doubtful if the ears and inner portion of the larger part of the stalk are touched.

2. The more immature the crop the more the damage and *vice versa,* because (*a*) frosting checks further development and (*b*) the plant, being in an immature state, is more easily decomposed by micro-organisms.

3. The contents of the ruptured cells fall an easy prey to bacteria, are decomposed, and their food value lessened or destroyed. It is doubtful if the organic matter already completely formed, such as fiber, starch and protein, is attacked. It is the material in *process of formation* that suffers deterioration.

4. The rupture of the cells causes the water content of the more tender portions of the plant to dry out rapidly, and these parts become brittle, break off and are lost.

How to handle Frosted Corn.

It would appear, therefore, that the losses are threefold: (*a*) further growth checked; hence, the earlier the frost, the more serious the loss; (*b*) chemical; (*c*) mechanical.

In case the corn is intended for the silo, the quicker the crop is ensiled the better. If the crop is not to be ensiled, it may be allowed to stand uncut for a week or two. It should be cut and stacked between September 20 and October 1. The extent of the injury, expressed in figures, is difficult to state. The greatest loss is evidently due to the checking of further growth, and the second greatest is probably mechanical, due to rapid drying and falling away of the leaves and external portions of the stalk. Palatability may be somewhat lessened. These combined losses are not as serious as are often imagined, the plant still retaining the larger part of its feeding value.

BEET SUGAR IN NEW ENGLAND.

J. B. LINDSEY.

The Massachusetts Agricultural College investigated the subject of sugar beet production in this State as early as 1870. In its eighth report for 1871 the late Professor Goessmann published a comprehensive review of the sugar industry — beet, sorghum and cane — both at home and abroad. A large amount of valuable data is therein collated.

In the report for 1872 he gave the results of experiments conducted upon the college farm and elsewhere and drew the following conclusions: —

1. It is possible to grow beets of high sugar content in Massachusetts upon well-drained mellow loams when proper attention is given to fertilization and cultivation.

2. Whether or not the industry will prove profitable in Massachusetts depends upon the area that is available for the cultivation of the beet, and whether the necessary capital can be secured to erect sugar factories for the extraction of the sugar.

Later, considerable beets were grown in the vicinity of Franklin, Mass., and a small factory erected for the manufacture of the sugar. This enterprise did not meet with success, owing, among other things, to the crude methods employed in the factory and the relatively small supply of beets available. The industry has languished since that time in this State, although it has thrived particularly in California and Michigan.

In order to make the industry a success large tracts of comparatively level land must be available, and the factory must be located as near the center of the area as possible. It is doubtful if the hill towns of the State would be suited to the conditions, the beets having to be transported to the factory either by rail or wagon. It is believed by the writer that the land in other portions of the State — the Connecticut valley, Worcester County, etc. — is more valuable for the production of other crops, such as tobacco, onions and vegetables, than it could be for the production of sugar beets. Brooks, in his book entitled "Agriculture," states his opinion as follows: —

> The production of sugar beets is hardly likely, in the opinion of the writer, to prove profitable in the New England States. In that section greater profits can be derived from the cultivation of numerous other crops to which the soil and climate are suited and which can be readily disposed of in the markets of that section of the country.

It is not true that beets improve the fertility of the land. Sugar beets thrive best in deep, rich mellow loams. Well-rotted stable manure, green crops plowed in, supplemented with phosphates and high-grade sulfate of potash, preferably applied in the autumn, are the most suitable fertilizers. It would be useless to try to grow sugar beets on shallow, unfertile soils. The writer is, therefore, of the opinion that while the climate is satisfactory and a considerable area is suited to the beet, economic conditions are not favorable to the production of beet sugar in Massachusetts.

MALNUTRITION OR OVERFERTILIZATION OF GREENHOUSE CROPS.

H. D. HASKINS.

Crops grown in greenhouses under somewhat artificial conditions are likely to suffer from a variety of troubles. In this paper data will be presented which strongly indicate that imperfect growth and development are due in many cases to an accumulation of soluble plant food rather than to fungi and bacteria.

Condition of Diseased Cucumber Crop.

The pathological description of the affected crop is briefly as follows: —

The plants, which at first are usually very vigorous, turn yellow prematurely and fail to develop fruit. The leaves become more or less spotted, resembling the mosaic troubles sometimes seen on other plants. When studied with the microscope no fungous disease is apparent. The trouble does not usually develop until the third year after the soil has been placed in the houses, and its appearance seems to depend wholly upon the manner in which the soil has been prepared and managed.

Method of preparing the Soil. — In those cases where the trouble has been experienced the third year, the preparation of the soil has consisted in mixing equal amounts of pasture sod and horse manure and allowing it to remain a couple of months before transferring it to the houses. Upon placing the soil in the houses more manure and also some lime were added, and when the cucumber plants were set a trench of horse manure and chopped straw was used beneath to furnish underground heat. During the growth of the crop a considerable quantity of nitrate of soda and chemical fertilizer was supplied. This treatment must necessarily result in a very rich soil which produces a heavy crop the first year.

The treatment of the soil the second year consisted in spading in a heavy layer of horse manure and in working into the soil the available portion of the manure which was used in the trenches for heat the previous year. Trenching with manure for underground heat was again resorted to, and the nitrate of soda and chemical fertilizers were used as in the previous year. This general treatment is followed for each successive crop until the result is a crop failure.

Chemical Analysis of Such Soils. — In the following table is given a chemical analysis of a soil which had served for three successive years in a greenhouse for cucumbers. In order that any one unfamiliar with the interpretation of soil analyses may understand the extent to which the plant food has accumulated, the average analysis of 38 samples of barnyard manure is given for comparison.

	Analysis of Cucumber Soil.	Analysis of Barnyard Manure, Average of 38 Samples.
Moisture,	36.72	73.38
Organic matter,	9.92	–
Nitrogen,	.55	42
Potash,	.48	.53
Phosphoric acid,	.51	.31
Calcium oxide,	1.12	–
Sodium oxide,	.43	–
Magnesium oxide,	.47	–

The above results show the cucumber soil to be considerably richer in nitrogen and phosphoric acid than are the better grades of mixed farm manures. Although this large amount of *total* plant food in the soil may be an *indication* that the soil is too fertile, yet it is probable that the injurious effect is due to the soluble or active portion of the constituents present.

Composition of Normal and Abnormal Soils. — Occasion is here taken to bring together some results of analyses of abnormal and normal cucumber soils. The abnormal soils were all sent at various times by parties having trouble with their crops, in some cases resulting in failure. The normal soils giving excellent results were procured by the writer from well-known growers in various localities in Massachusetts.

The laboratory method of examining the soil consisted in leaching 400 grams with 1,000 cubic centimeters of hot water; the resulting solution was evaporated to dryness on a water bath and a chemical analysis made of the residue. The results in Table No. 1 have been computed to parts in 100 parts of dry soil for the sake of comparison.

TABLE NO. 1. — *Showing Per Cent. of Water Soluble Constituents in 100 Parts of Dry Soil.*

	ABNORMAL SOILS.					NORMAL SOILS.		
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	A.	B.	C.
Total water soluble salines,	1.840	1.680	1.136	.5402	.50430	.456	.2940	.190
Soluble nitrogen,	.050	.012	.102	.0532	.02332	.025	.0055	.025
Soluble potash,	.500	.410	.238	.1123	.14360	.085	.0550	.026
Soluble phosphoric acid,	.040	.045	.020	.0201	.00630	.017	.0007	.002
Soluble calcium oxide,	.064	.045	.057	.0359	-	.047	.0310	.030
Soluble sodium oxide,	.220	.210	.192	.0236	.03200	.068	.0600	.075
Soluble magnesium oxide,	.054	.036	.031	-	-	.022	.0090	.009
Soluble sulfates (SO_3),	.069	.036	.050	-	-	.049	.0290	.008

In this table should be noted the large amount of total and single soluble mineral constituents in the abnormal as compared with those in the normal soils. A number of interesting facts are brought out in the analytical results. Note, for example, the large amount of water soluble potash as compared with the total potash content of the soils. In case of soil No. 3, the total potash was .76 per cent., of which .24 per cent. was found present in water soluble form. The amount of phosphoric acid present in the water solution of the soil is quite exceptional. The writer has never found but two samples of out-of-door soil which showed more than mere traces of phosphoric acid in water soluble form, and these two samples were tobacco soils showing strong indications of overfertilization. The presence of a comparatively large amount of soluble nitrogen was to be expected.

To bring out in a more striking manner the differences in the two types of soil, the results have been computed in Tables Nos. 2 and 3, on the basis of pounds of the various constituents per acre of soil containing 20 per cent. moisture.[1]

TABLE NO. 2. — *Showing the Average Composition of the Abnormal as compared with the Normal Soils.*

	POUNDS PER ACRE	
	Abnormal Soils. Average of Five Analyses.	Normal Soils. Average of Three Analyses.
Total water soluble salines,	27,363	7,520
Soluble nitrogen,	1,156	444
Soluble potash,	6,743	1,328
Soluble phosphoric acid,	632	208
Soluble calcium oxide,	1,211	864
Soluble sodium oxide,	3,259	1,624
Soluble magnesium oxide,	966	320
Soluble sulfates (SO_3),	1,240	727

This table shows a marked increase of soluble plant food in the abnormal soils. To express this amount of plant food in terms of fertilizers, a calculation shows that to furnish the nitrogen would require 3¾ tons of nitrate of soda; to furnish the potash, 6¾ tons of high-grade sulfate of potash; to furnish the phosphoric acid, 2 tons of 16 per cent. acid phosphate; and to furnish the lime, 1 ton of hydrated lime. To express the results in terms of a mixed fertilizer made up of the highest grades of material it would require an application of 14½ tons of a formula testing 4 per cent. nitrogen, 23 per cent. actual potash and 2.25 per cent. available phosphoric acid. It should be understood that the results given in the above table represent only that portion of the plant food which is *soluble in water.*

In Table No. 3 is shown the variation in composition of the different samples in both types of soil.

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[1] Assuming that an acre of soil 1 foot in depth weighs 3,000,000 pounds.

TABLE No. 3. — *Showing the Pounds of Water Soluble Constituents in an Acre of the Different Soils with Average Moisture Conditions (20 Per Cent.).*

	ABNORMAL SOILS.					NORMAL SOILS.		
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	A.	B.	C.
Total water soluble salines,	44,160	40,329	27,300	12,965	12,063	10,914	7,056	4,560
Soluble nitrogen,	1,200	288	2,457	1,277	558	600	132	600
Soluble potash,	12,000	9,840	5,733	2,695	3,446	2,040	1,320	624
Soluble phosphoric acid,	960	1,080	491	482	150	408	168	48
Soluble calcium oxide,	1,536	1,080	1,365	862	-	1,128	744	720
Soluble sodium oxide,	5,280	5,010	4,641	566	768	1,632	1,440	1,800
Soluble magnesium oxide,	1,296	864	737	-	-	528	216	216
Soluble sulfates (SO_3),	1,656	864	1,201	-	-	1,296	696	192

All of the abnormal soils are shown to contain more water soluble salines than do the normal soils, although in two instances the difference is not marked. The amount of the various constituents which make up the total soluble salines differs widely in the several samples, the range being fully as great in the normal as in the abnormal soils. The amount of potash and magnesia is greater in all of the abnormal than in the normal soils. The other constituents — nitrogen, phosphoric acid, calcium oxide, sodium oxide and soluble sulfates — are present in larger quantities in some of the normal soils than in the abnormal, although this is not true when the averages are compared, as has been shown in Table No. 2.

The wide variation in the amounts of the various soluble constituents, and the fact that some of them are found in larger amounts in the normal than in the abnormal soils, would indicate that the injury was not due to the toxic effect of any one constituent, but rather to the combined effect of the total soluble mineral matter.

A further study of Table No. 3 would indicate that the safe limit of concentration of the soluble ingredients is around .5 per cent. on the basis of 100 parts of dry soil, or 12,000 pounds per acre foot with normal moisture. On this basis it could be assumed that sample A, which is listed in the table as a normal soil, was very near the danger mark, and no doubt it would be good judgment to remove one-third of this soil and replace with new before putting in another crop. That it is not necessary to have such an excessive amount of soluble plant food present in order to grow satisfactory crops is proved by a reference to sample C, listed under normal soils, which had been used for three seasons with very satisfactory results. Note the comparatively small amount of total and individual soluble salines present.

In case of this latter soil, about one-half of the organic matter was derived from air-dried peat. The abundance of organic matter present insured suitable mechanical conditions as well as the conservation of moisture. The writer is of the opinion that a good quality of well-cured, air-dried peat, or even waste from cotton mills, might be used to good advantage when preparing the soil, in place of one-half of the horse manure which is generally used. The use of peat would, of course, necessitate an abundant application of lime (about 5 bushels per cord of peat), and the soil should be mixed several months before being placed in the houses, and should be worked over at least twice during that time.

The above inquiry has been confined to the cucumber crop, but almost any plant may suffer from overfertilization. It may be stated that the various plant families differ in their ability to withstand the effect of concentrated soil solutions. The growth of young tobacco plants has been checked and the plants seriously injured by about one-eighth as much water soluble salines as were shown to be contained in the average abnormal cucumber soil.[1]

Effect of Overfertilization on Sweet Peas.

Some of the crops grown by florists often suffer from the effect of malnutrition. In 1911 four samples of soil upon which sweet peas had been growing were forwarded to the station for examination. Two of the samples were from houses showing a satisfactory normal growth, and two were from houses where the plants were unproductive and were suffering badly from some cause. Dr. Stone, the plant pathologist, examined specimens of the plants under the microscope, but failed to find them suffering from any disease caused by bacteria, and suggested a chemical examination of the soil.

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[1] See article entitled, "Tobacco Injury due to Malnutrition or Overfertilization," in Part II of the twenty-fourth annual report of this station, pp. 35-47.

The soils were washed out with hot water, and after the water solution had been evaporated to dryness an analysis was made of the residue. The average results have been figured to 100 parts of dry matter for the sake of comparison.

	Average Analysis of Two Normal Soils.	Average Analysis of Two Affected Soils.
Total water soluble salines,	.5364	.6331
Soluble nitrogen,	.0087	.0039
Soluble potash,	.1013	.1232
Soluble phosphoric acid,	trace	trace
Soluble calcium oxide (lime),	.0241	.0274
Soluble magnesium oxide,	.0154	.0185
Soluble sodium oxide,	.0405	.0801

In the following table the above results have been calculated so as to express the amount of constituents present in pounds per acre foot with normal soil moisture (20 per cent.): —

	Pounds per Acre.	
	Average of Two Normal Soils.	Average of Two Affected Soils.
Total water soluble salines,	12,874	15,193
Soluble nitrogen,	209	91
Soluble potash,	2,433	2,957
Soluble phosphoric acid,	traces	traces
Soluble calcium oxide (lime),	580	657
Soluble magnesium oxide,	369	445
Soluble sodium oxide,	972	1,923

These figures show the affected soil to contain a considerably larger amount of total soluble salines and, with the exception of nitrogen, a larger amount of the individual soluble mineral constituents than do the normal sweet-pea soils. Even the normal soils show a very liberal amount of water soluble plant food.

The normal soils showed the presence of .46 per cent. of total nitrogen, and the affected soils .66 per cent., mostly in organic form. The appearance of the soils indicated that a large amount of horse manure had been used in their preparation.

Soils to be used for sweet-pea culture should not have an excessive amount of available nitrogen present, as it produces a large watery growth of stem and leaf which results in weakening the plant and is unfavorable to blooming. The soils examined were noticeably acid, a condition undesirable for this crop.

Discussion and Suggestions.

The results of our observation on all of the above greenhouse soils suggest that there is a serious fault in the construction of the beds and benches in many cases. Good drainage should always be provided, and, in fact, is more important in the greenhouse than in the open. The soil in the former case is made much more fertile and does not have the benefit of occasional heavy rains to cause leaching, as in the case of the out-of-door soil. In the field there is always a free movement of soil water after each heavy rain, and analyses show the drainage water to contain an appreciable amount of the various mineral constituents. In fact, large quantities of soluble residual salines are thus removed from the soil each year.

A sufficient amount of all the elements of plant food in suitable and available forms should, of course, be supplied, and a certain excess is even essential in order that the crop may make a quick growth and be ready for the early market. Too great an excess of horse manure should be avoided, however, and chemical plant food should be used with the same care and judgment that would be used when applying them to crops grown in the open field. If 500 pounds of high-grade sulfate of potash are considered the maximum amount to be applied per acre (4,840 square yards), then 1.6 ounces would be the maximum amount to apply per square yard in the greenhouse. In other words, a calculation can easily be made for the application of all fertilizing materials in the greenhouse, and if this were always done instead of relying upon guesswork, cases of overfertilization would not be so frequent, and just as satisfactory crops would be grown.

To give an approximate idea of the total amount of plant food, as well as the available plant food furnished by horse manure when mixed with the soil in various proportions for use in the greenhouse, the following table has been prepared: —

	Pounds of Total Plant Food per Acre.			Pounds of Plant Food likely to be available the First Season.		
	A.	B.	C.	A.	B.	C.
Nitrogen,	5,800	3,863	2,900	2,320	1,545	1,160
Phosphoric acid,	2,800	1,850	1,400	2,380	1,585	1,190
Potash,	5,300	3,530	2,650	3,971	2,648	1,985

"A" represents one-half manure and one-half soil; "B," one-third manure and two-thirds soil; "C," one-fourth manure and three-fourths soil.

Wherever indications of overfertilization appear, the soil should be leached out with hot water as soon as the crop is removed. In fact, it is believed that a thorough leaching of greenhouse soil at least once each year would be very beneficial in removing excessive residual salines. The leaching may sometimes be accomplished with water from which the chill has been removed while the crop is still in the ground. Good drainage should always be provided whenever this is undertaken. If the conditions are not favorable for leaching, in case of the cucumber crop, about 3 inches of fresh loam should be applied to the surface of the bed and worked in lightly around the plants. This promotes the formation of new roots and has been known to save the crop.

After the removal of the crop, from one-third to one-half of the soil in the benches should be replaced with new loam before replanting. The removed soil as well as the solution resulting from leaching may be used to good advantage as a fertilizer on out-of-door crops, and would probably prove equal to the average farmyard manure.

TOBACCO STALKS AS A FERTILIZER.

H. D. HASKINS.

Many manufacturing industries are to-day supplying valuable by-products which have become recognized sources of available plant food. Thirty years ago some of these by-products were considered of no special value, and were disposed of in the most convenient manner. In more recent years, as the demand for plant food has increased, manufacturers have been led to investigate the fertilizing value of their by-products. The farm, also, has waste products which should be carefully preserved and used in the most approved manner. The residues from different crops may vary widely in value, depending upon the character and habit of the plant as well as upon the nature of the material itself.

Tobacco furnishes perhaps as large a proportion of valuable refuse material as any of the various farm crops grown in Massachusetts. Since tobacco is a heavy feeder as well as a large plant, and as it is cut before the plant has a chance to develop its seeds, one may expect to find a large quantity of the plant food constituents in the stalk. It is also possible that a movement of plant sap takes place from the leaf to the stalk during the curing process.

The following analyses show the composition of tobacco stalks from which the cured leaf has been stripped (usual process of curing), also stalks from which the green leaf has been picked in the so-called "priming" system of harvesting the crop.[1] Both analyses have been calculated to the basis of 100 parts of dry matter.

---

[1] The wide difference in composition of the two kinds of stalks cannot, perhaps, be wholly attributed to method of harvesting, as they represent two different types of the tobacco plant.

	Tobacco Stalks, stripped. Havana Seed Leaf (Per Cent.).	Tobacco Stalks, Priming System. Tent-grown (Per Cent.).
Nitrogen,	3.25	1.10
Potash,	4.95	1.00
Phosphoric acid,	.78	.26

Only a relatively small amount of tobacco is "primed" at the present time, but this method of harvesting seems to be growing in favor. In either case the stalk has valuable fertilizer properties which, if handled in the right manner, become of considerable importance in maintaining soil fertility.

Statistics tell us that 5,700 acres were devoted to the tobacco crop in Massachusetts for the year 1912. Communication with several of the large tobacco growers brings out the fact that on an average 8,666 Havana seed leaf plants are grown per acre. The average weight of 10 stalks from which the leaf had been stripped was found to be 6.58 pounds,[1] which, computed on an acre basis, would amount to 5,702 pounds. It was found that the water content of the stalks from different localities varied considerably, the average being 52.94 per cent. In other words, 3,018 pounds out of the total weight of stalks per acre were found to be water, and 2,684 pounds, dry matter.

The analysis of two samples of stalks grown by the usual method showed the following chemical composition on a dry-matter basis: —

	Stalks received from Oscar Belden & Sons, Bradstreet, Mass. (Per Cent.).	Stalks received from G. P. Smith, Sunderland, Mass. (Per Cent.).
Phosphoric acid,	.74	.82
Potassium oxide,	5.23	4.67
Total nitrogen,	3.00	3.49
Water soluble organic nitrogen,	2.01	2.52
Active water insoluble organic nitrogen,	.25	.23
Inactive water insoluble organic nitrogen,	.74	.74

---

[1] Weights secured in three different sections of the Connecticut valley.

On the basis of the above figures, the stalks on an acre would contain the following amounts of plant food: —

Nitrogen,	87.23
Potash,	132.85
Phosphoric acid,	20.94

Applying the same commercial values that are usually given to the plant food found in cottonseed meal, castor pomace and other organic vegetable substances, the total value of the stalks per acre would be about $24, or about $8.40 per ton of partially dried stalks.[1] If this same valuation is applied to the total product of the State, the commercial value of the plant food found in the tobacco stalks grown in Massachusetts for the year 1912 amounts to $136,800.[2]

The usual method of handling tobacco stalks is as follows: the stalks from which the leaf has been stripped are thrown out upon the land during the fall and allowed to remain until spring, thus permitting the rains and snows to dissolve any valuable fertilizing material which the stalks may contain. They are then placed in small piles, burned and the ashes scattered over the adjoining land. If all of the plant food were washed out of the stalks by leaving them thus exposed, this perhaps would be an economical manner of disposing of the material, but even then there would be the loss of a large amount of organic matter which eventually would have furnished humus.

The matter appeared to be of sufficient importance to warrant a few chemical tests to see to what extent the plant food was removed by the exposure of the stalks upon the land during the fall and winter months. Stalks thus exposed were procured under average conditions and subjected to a chemical analysis with the following results (calculated to a dry-matter basis): —

---

[1] By "partially dried" is meant a material containing 50 to 53 per cent. moisture; the green stalks at stripping time may contain from 70 to 75 per cent. moisture.

[2] This valuation is somewhat high for the reason that the labor cost of handling a definite amount of plant food in tobacco stalks would be greater than that of handling the same plant food in cottonseed meal.

	Nitrogen (Per Cent.).	Potash (Per Cent.).	Phosphoric Acid (Per Cent.).
Unexposed stalks,	3.25	4.95	.78
Leached stalks,	1.39	2.44	.70
Amount dissolved,	1.86	2.51	.08

The above data show that the exposed stalks have lost by leaching about 57 per cent. of the total nitrogen and 51 per cent. of the total potash contained in the original stalks. The form in which the nitrogen was present in the unexposed stalk was also determined. Ground, air-dried, unexposed stalks testing 3.29 per cent. nitrogen (3.49 per cent. on a dry-matter basis) were tested for nitrates, albuminoid nitrogen and amid compounds, with results as stated below: —

	Per Cent. in Dry Matter.
Nitrogen as nitrates,	1.29
Nitrogen in form of amid compounds,	1.20
Albuminoid nitrogen,	1.00
Total nitrogen,	3.49

It is quite probable that the leaching process removes most of the nitric nitrogen and a large proportion of the more soluble amid compounds, and that the residual nitrogen found in the exposed stalks is present largely in albuminoid form and is somewhat more slowly available to plants than the soluble portion. The usual practice of burning the stalks would of course result in the loss of this water insoluble nitrogen only, as the potash and phosphoric acid would remain in the plant ash. In the process of burning, an average of about 37.31 pounds of nitrogen (valued at $7) would be lost for every acre of tobacco grown. This would represent a value of $39,900 in Massachusetts, without considering the loss of the organic matter (some 2,000 pounds to the acre).

It is believed that the most economical way for large tobacco growers to handle this material is to cut the partially dried stalks as soon as possible after stripping, by means of an ensilage cutter, into pieces an inch or so in length, spread them broadcast upon the land in late fall and plow them under in the spring. If it seems desirable to allow the uncut stalks to remain on grass land during the winter as a top dressing, they may be gathered in the spring, spread upon land intended for corn and plowed under. The leached stalks will be pretty thoroughly decomposed during the year and will not cause any inconvenience the following season.

INSECT RECORD FOR 1912 IN MASSACHUSETTS.

H. T. FERNALD.

The correspondence received by the experiment station during 1912 was unusual because of its scope, nearly 400 different insects being subjects of inquiry.

As was to be expected, heat and a dry period were favorable for plant-lice of many kinds and for the San José scale, and these pests were much in evidence everywhere, over a hundred separate inquiries being received referring to plant-lice. The elm-leaf beetle was also abundant, and where not cared for by spraying, caused much injury.

Ants in houses and in lawns, cutworms, wireworms, various soft scales, the squash vine borer, asparagus beetles, the spiny elm caterpillar and the gypsy and brown-tail moths were also the subjects of many letters, and these, with the other pests mentioned, formed the bulk of the correspondence.

The birch-leaf skeletonizer, *Bucculatrix canadensisella* Chamb., has attracted little attention this year, and it seems probable that it will not be noticeable another fall. The work of the bronze birch borer, *Agrilus anxius* Gory, has been much in evidence, but while many cut-leaved white birches succumbed to its attacks during the first year or two it was present, some now appear to be more resistant and more or less immune. At one time it seemed as though all of these trees would be destroyed; at present it seems possible that some of them may escape.

Numerous egg clusters of the apple-tree tent caterpillar, *Malacosoma americana* Fab., sent in for identification; inquiries about the apple-twig borer, *Schistoceros hamatus* Fab., the bud moth, *Spilonota ocellana* Schiff., and apple aphids indicate that more careful attention than ever before is being given to the apple trees of the State, and in general a closer examination of our crops, in order to protect them from injury, is evident.

Flies, fleas, roaches, bedbugs and other household pests have required considerable correspondence during the year; and it would seem that whenever anything unusual made its appearance anywhere in the State in insect lines, it aroused sufficient interest to lead to inquiries.

During the latter part of September, 1911, an unusual abundance of cotton-worm moths, *Alabama argillacea* Hbn., was noted, and this was also the case almost everywhere through the northern States. Another, but smaller, flight of these moths took place this year, only a single specimen being captured at Amherst. As, so far as known, this insect feeds only on cotton, its appearance so far from where it normally occurs is always of interest.

One brood of the seventeen-year locust or cicada, *Cicada septendecim* L., due in 1911, has never been reported from Massachusetts though abundant in northwestern Connecticut and eastern New York. During that year specimens were captured in New York only about three miles from the Massachusetts State line. Under these circumstances it is probably safe to consider this brood as also occurring in southwestern Massachusetts, though perhaps in limited numbers.

The discovery in January, 1912, of more than 50 specimens of a lady beetle, *Hippodamia ambigua* Lec., in bunches of celery purchased in the market at Amherst, is of interest, as the beetles are natives of the Pacific coast and the celery came from California. Fortunately, these insects are beneficial, but injurious forms could easily be introduced into Massachusetts in similar ways and add to our already too long list of enemies to fight here.

The juniper scale, *Diaspis carueli* Targ., a European foe of the juniper and arbor vitæ, was found during the year in such abundance on plants imported from abroad as to seriously injure them. This insect has already been found in a number of places in this country, probably in all cases having been received from Europe. A serious attack on valuable hedges of box by the box-leaf miner, *Monarthropalpus buxi* Lab., in some parts of southeastern Massachusetts and in Rhode Island, has also been observed, and studies on this insect and methods for its control have been begun. This insect which has evidently come to this country from Europe has already been reported by Dr. Felt (Journ. Econ. Ent. III., 342, 1910).

The cottonwood leaf beetle, *Lina scripta* Fab., was observed feeding on the leaves of poplars in a nursery at Agawam in the fall of 1910, since which time it has been found elsewhere in the Connecticut valley. This insect is well known farther west, and appears to be spreading eastward. Possibly its presence in Massachusetts has already been recorded, but no such reference has been noticed by the writer.

The chestnut borer, *Leptura zebra* Oliv., has been found in numerous instances working on chestnut trees, as reported last year, and has been so often observed in connection with the chestnut bark disease that the claim has been made that it is often the cause of the death of the tree, and that the disease attacks only trees already weakened by this insect. This view in the light of such evidence as is at hand can hardly be accepted, but there is no doubt that trees weakened by this insect would be even more likely to die from the disease on this account.

The fall army worm, *Laphygma frugiperda* S. and A., has been unusually abundant and destructive this year, particularly in eastern Massachusetts. According to reports received this has also been true in many parts of the country.

White ants or termites, *Termes flavipes* Koll., have been reported as injuring the stems of growing cabbage and corn plants, leaving only the outside of the stem. As no other insects could be found in the stems, while the termites were abundant there, it would seem probable that in this case living tissues had replaced the more usual food of these insects, which is dead or decaying wood.

TESTS OF INSECTICIDES.

H. T. FERNALD.

It has not been the policy of the department of entomology of this station to conduct tests of the different insecticides on the market, the department having no trees under its control upon which to make the tests. In a few cases, however, special reasons have led to a departure from this rule, and the results of a few trials of such materials are given here. No attempt is made to draw final conclusions in any case, those given being only such as the tests themselves indicated. It is recognized that farther trials of these materials in other localities, or perhaps under different climatic conditions, might give different results, but as such are not available only those actually obtained here are recorded.

Entomoid. — Manufactured by Frank M. Hale, Woonsocket, R. I. This material was tested in 1911, and the results are given in the last annual report. Entomoid is claimed to be a combination of lime-sulfur and a miscible oil, and should possess the good qualities of both of these materials. The manufacturer believed that a modification of the formula used in 1911 would be an improvement, and it was this modification which was used in 1912. Several apple, pear and plum trees and currant bushes considerably infested with San José scale were sprayed with it, following directions supplied by the manufacturer to dilute 1 part of the Entomoid with 50 parts of water. On two trees a dilution with 40 parts of water was used instead, in order to determine any possible injury by a stronger solution or possibly a greater effectiveness. The treatment was applied April 17, the day being calm, cloudy and with a temperature of 65° to 70° during the treatment. The material mixed easily with water and sprayed well and was dry within a short time. There was quite a heavy rain that night and also some the next day.

As a whole, the results were less satisfactory than in 1911. Whether this difference was due to the difference in the maker's formula, to the rain following within twelve hours, or to the greater dilution (in 1911 with the old formula it was 1 to 20 and 1 to 30), it is impossible to determine. Many of the scales were certainly killed, but enough were left so that the trees were about in their former condition at least three months earlier than was the case in 1911. It may be that the dilution with the new formula material was greater than should have been the case; but the relative concentration of the two materials was, of course, known to the maker, who should accordingly have been able to advise the proper dilution for the second formula to make it properly compare with the first. No difference in results was noted with the two dilutions used.

It may be said of this material that thus far it seems to have some value as a scalecide, but that farther experimental work by the inventor, followed by more field tests of the materials thus produced, will be needed before any final formula can be established.

Nicine. — Manufactured by the Hood Chemical Company, Chicago. This substance appears to be widely used as an absorbent, deodorant and germicide. It is also claimed that it will prevent the hatching of the eggs of insects and will drive away flies. It is "a success when blown on trees and shrubs in destroying insects and fungus."

A claim made in letters from the company, "that it limits the activities of root parasites of all kinds," led to testing this substance both for the protection of corn from wireworms and of onions from the onion maggot. For the corn two plots about a thousand feet apart were taken, and in each, rows were treated in twos, alternating with two untreated, used as checks. The rows were about three feet apart. The Nicine was poured into the drills in fairly large amounts, was then covered slightly and the corn planted over it.

It was anticipated that the plots would be quite badly infested with wireworms, but unfortunately for the success of the test these proved to be rather scarce, and on this account the experiment can hardly be considered a success. The only conclusions which could safely be drawn from the work were the rather negative ones that this treatment had at least no injurious effect on the plants, and that it did not give absolute protection, as a few hills both in the treated and untreated rows were attacked by wireworms, though too few to give evidence of any value.

The tests of this substance for protection against the onion maggot were limited by the small amount available. Two rows of plants were treated, the Nicine being liberally applied around the bases of the plants when they were about an inch and a half high. At this time no maggots could be found anywhere in the field. The Nicine was evident at the bases of the plants for several weeks, but did not wholly protect the plants from maggots, at least, as a few were attacked. Compared with rows treated by other methods, it did not even afford a high degree of protection, but as maggots were not particularly abundant anywhere in the field, and the crop did not "catch" well, the whole test can hardly be regarded as conclusive.

Soil Fumigant and Insecticide. — Manufactured by the Sherwin-Williams Company, Cleveland, O. This material was to have been tested in 1911, but the shipment was lost and not recovered until too late in the season for use. It was applied in the spring of 1912 to parts of the same corn plots described under Nicine above, and in the same manner, though a little more liberally.

For the same reasons as in the case of Nicine the test can hardly be regarded as proving anything. The corn in the treated rows differed little in growth and product from that in those untreated, and the wireworms proved not to be sufficiently abundant to enable any determination of its value to be possible. Tests of this material in Maine and Minnesota during 1911 have been reported as giving no evidence of its value as a protection from the attacks of insects.

Zinc Arsenite. — Received from the Sherwin-Williams Company, Cleveland, O. The company suggested using this at the rate of 1 pound to 10 gallons of water, "in the absence of sufficient data of a practical nature and based only on its chemical composition," and this suggestion was followed.

The material was applied quite freely to elm, maple and wild cherry leaves, July 8, no fruit trees being available for the purpose. Elm-leaf beetle larvæ were abundant on the elm, but the application to the other plants was entirely to determine the danger of injury to the foliage.

In all cases the sprayed leaves were conspicuous until the leaves turned in the fall, indicating an excellent adhesive property. On the elm the beetle larvæ were quickly killed, and after a short time injury to the leaf tissue around each place where a beetle had fed became evident.

After two weeks an examination of the plants sprayed showed that all had been injured by the treatment, the material having evidently been applied too strong. Tests at other places, reports of which were received after the tests here had been made, indicate the same thing, and it is now the intention to continue the experiments the coming season, to determine the best strength of the arsenite to use for effectiveness against insects and at the same time avoid injury to foliage, using various fruit and shade trees for the purpose.

It was noted in the course of the work that the arsenite did not remain long in suspension, and continuous agitation was necessary to insure an even distribution.

Zinc Arsenite. — Received from the California Spray Chemical Company, Watsonville, Cal., for trial. Tests of this were made at the same time and in the same way as with the other arsenite of zinc, as described above. The material appeared to settle rather more quickly than the other, but no other differences were noticed. It is evident that in this case, also, the application was too strong. It is quite certain that settling of both of the samples of arsenite of zinc can be materially delayed by the addition of soap, as has been shown by Parker (Montana Bulletin No. 86) and others.

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PART II.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTY-FIRST YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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Massachusetts Agricultural Experiment Station.

OFFICERS AND STAFF.

COMMITTEE.

Trustees.

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WILFRID WHEELER,	Concord.
CHARLES E. WARD,	Buckland.
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The President of the College, *ex officio*.
The Director of the Station, *ex officio*.

STATION STAFF.

Administration.

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JOSEPH B. LINDSEY, Ph.D., *Vice-Director*.
FRED C. KENNEY, *Treasurer*.
CHARLES R. GREEN, B.Agr., *Librarian*.
Mrs. LUCIA G. CHURCH, *Clerk*.
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HENRY J. FRANKLIN, Ph.D., *In Charge Cranberry Substation*.
EDWIN F. GASKILL, B.Sc., *Assistant Agriculturist*.

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FRED W. MORSE, M.Sc., *Research Chemist*.
HENRI D. HASKINS, B.Sc., *Chemist in Charge (Fertilizer Section)*.
PHILIP H. SMITH, M.Sc., *Chemist in Charge (Food and Dairy Section)*.
LEWELL S. WALKER, B.Sc., *Assistant Chemist*.
RUDOLF W. RUPRECHT, B.Sc., *Assistant Chemist*.
CARLTON P. JONES, M.Sc., *Assistant Chemist*.
CARLOS S. BEALS, B.Sc., *Assistant Chemist*.
WALTER S. FROST, B.Sc., *Assistant Chemist*.
JAMES P. BUCKLEY, Jr., *Assistant Chemist*.
JAMES T. HOWARD, *Inspector*.
HARRY L. ALLEN, *Assistant in Laboratory*.
JAMES R. ALCOCK, *Assistant in Animal Nutrition*.
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Miss REBECCA L. MELLOR, *Clerk*.

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Horticulture.	Frank A. Waugh, M.Sc., *Horticulturist.* Fred C. Sears, M.Sc., *Pomologist.* Jacob K. Shaw, Ph.D., *Research Pomologist.* John B. Norton, B.Sc., *Graduate Assistant.*
Meteorology.	John E. Ostrander, A.M., C.E., *Meteorologist.* E. K. Dexter, *Observer.*
Poultry Husbandry.	John C. Graham, B.Sc., *Poultry Husbandman.* Hubert D. Goodale, Ph.D., *Research Biologist.* Miss Fay L. Milton, *Clerk.*
Vegetable Pathology and Physiology.	George E. Stone, Ph.D., *Vegetable Physiologist and Pathologist.* George H. Chapman, M.Sc., *Research Vegetable Physiologist.* Orton L. Clark, B.Sc., *Assistant Vegetable Physiologist and Pathologist.* Miss Jessie V. Crocker, *Clerk.*
Veterinary Science.	James B. Paige, B.Sc., D.V.S., *Veterinarian.*

REPORT OF THE DIRECTOR.

WM. P. BROOKS.

ADMINISTRATION.

Station Staff.

From Oct. 1, 1912, to September, 1913, thus including the greater part of the director's leave of absence, the administrative duties of the office were faithfully and ably discharged by Mr. F. W. Morse, research chemist in agronomy, of our department of chemistry. It is a pleasure to testify not only to the fine tact and good judgment shown in a position necessarily somewhat difficult to fill, but as well to express appreciation of the effective initiative shown by Mr. Morse at a time particularly critical in the financial relations of the station to the State. The material increase in the annual provision made by the last Legislature for the support of the station, reported in detail under a topic considered later, is the best evidence of the quality of his work. It is a pleasure, also, to say that in all the phases of the work of the director's office the vice-director, Dr. J. B. Lindsey, took his accustomed hearty interest, gave most freely of his time, and contributed no little to its successful administration. The splendid *esprit de corps* shown by all the members of the staff should also be mentioned. Each fully met the responsibilities of his position, and more; and it is in a sense invidious to recognize especially the services of the first clerk of the administrative department, Mrs. L. G. Church, and the assistant agriculturist, Mr. E. F. Gaskill, to whom, however, inevitably fell an unusual share of the duties usually devolving upon the director and agriculturist.

On the resumption of my duties as director on September 1 Professor Morse was once more able to devote his entire time to the important lines of research connected with the nutrition of asparagus and the cranberry, and the specific effects of certain fertilizer chemicals upon the soil, in which he has been engaged for the past few years.

The station has been fortunate in retaining the services of all the senior members of its staff. This has been strengthened and the scope of its work increased by the appointment on February 1 of H. D. Goodale, Ph.D., as research biologist in the poultry department. Other new appointments in the same department are Mr. J. W. Sayer, foreman, Mary R. Kingsbury and Fay L. Milton as clerks, the latter replacing Miss Kingsbury in September. An added assistant was rendered necessary by the increase in the amount of work connected with the inspection of commercial fertilizers, and W. S. Frost, B.Sc., of Tufts College, was appointed assistant chemist. John B. Norton, B.Sc., University of Vermont, was appointed to the vacancy as graduate assistant in horticulture in May. Miss Lina E. Fisher, who had given one-half her time to the clerical work of the department of chemistry, was transferred in October to the chemical department of the college, her place being taken by Miss Rebecca L. Mellor, who similarly gives one-half her time to the clerical work of the department of chemistry. Mr. James C. Reed, who for several years had served as assistant, a considerable portion of the time in the research section, resigned in June to accept a position as chemist in connection with the manufacture of commercial feeds. His place was filled by the appointment of Mr. J. P. Buckley, who had taken courses of study in the Massachusetts Institute of Technology.

Geo. H. Chapman, research vegetable physiologist and pathologist, was granted eight months leave of absence, beginning September 1. Mr. Chapman will spend most of his time in study abroad. Orton L. Clark, B.Sc., was at the same time employed in the department, and is engaged in important lines of research.

Maintenance.

At the beginning of the fiscal year, Dec. 1, 1912, the increase in the State appropriation for the support of the experiment station from $10,500, at which figure it had stood for many years, to $15,000, as provided by the Legislature of that year, became effective. The Legislature of 1913 passed an act increasing the annual State appropriation for investigation $5,000 per year for five years, beginning Dec. 1, 1913.

Other sources of income to the station have remained practically unchanged, and the gradual increase in the amount received from the State provided by the act just referred to will hardly suffice to enable the station to increase the scope of its work with the constantly broadening horizon and to meet the rapidly increasing demands upon it for service.

The federal appropriations have remained unchanged for three years. The amounts received from products sold, for labor for other departments of the institution, for chemical work and cow testing are subject to variation from year to year and cannot be estimated with entire safety in making up the annual budget. It is true, however, that the aggregate usually reaches a considerable sum. The amounts received during the past year are shown in the general table. The receipts from the sale of cranberries produced at the substation in Wareham were exceptionally large, as the crop was the most abundant produced since it has been the property of the station.

Attention is called to the fact that the fees received for the inspection of commercial fertilizers and the State appropriation for the execution of the feed law are almost entirely required in meeting the expenses connected with our control work. The amended laws now upon the statute books, however, provide that unexpended balances may be used in case of the fertilizer control work for investigations in relation to the use of manures and fertilizers, and in the case of the feed law for investigations in relation to foodstuffs and the feeding of farm animals. The balances so expended during the past year have been: —

From the fertilizer inspection, ...	$516 16
From the feed law appropriation, ...	350 00

Total Revenue for the Fiscal Year Dec. 1, 1912, to Dec. 1, 1913.

State appropriation,	$15,000 00
Federal appropriations: —	
Hatch fund,	15,000 00
Adams fund,	15,000 00
Agricultural department sales and labor,	2,740 01
Chemical department analytical work, cow testing, etc.,	9,038 81
Fertilizer law, analysis fees,	10,580 00
Feed law, State appropriation,	6,000 00
Cranberry substation: —	
Sales of fruit,	5,671 82
Sales of vines,	19 65
Meteorological observations, scientific services, etc.,	193 03
Total,	$79,243 32

The total amount available for investigation is about $16,000 less than the above total, about that sum being required for the execution of the feed and fertilizer laws.

The treasurer's report in full will be found on pages 40*a* and 41*a*.

PUBLICATIONS.

The following is a complete list of the station publications for the fiscal year just ended: —

Annual Report.

Twenty-fifth Annual Report: Part I., 240 pages; Part II., 97 pages.

Separata from Annual Report.

Report of the Cranberry Substation, 28 pages.
Report of the Botanist, 104 pages.
Report of the Entomologist, 21 pages.
The Inheritance of Blossom Color in Beans, 24 pages.

Bulletins.

No. 143. Inspection of Commercial Fertilizers, by H. D. Haskins, L. S. Walker, C. P. Jones and C. L. Beals; 93 pages.
No. 144. The Relation of Light to Greenhouse Culture, by G. E. Stone; 40 pages.
No. 145. Record of the Station Dairy Herd and the Cost of Milk Production, by J. B. Lindsey; 31 pages.
No. 146. Inspection of Commercial Feedstuffs, by P. H. Smith and C. L. Beals; 61 pages.

Circulars.

No. 35. Poultry Manures, their Treatment and Use; revision of No. 22; 4 pages.

Meteorological Reports.

Twelve numbers, 4 pages each.

PUBLICATIONS AVAILABLE FOR DISTRIBUTION.

Bulletins.

No. 33. Glossary of Fodder Terms.
No. 115. Cranberry Insects.
No. 123. Fungicides, Insecticides and Spraying Directions.
No. 130. Meteorological Summary — Twenty Years.
No. 133. Green Crops for Summer Soiling.
No. 134. The Hay Crop.
No. 137. The Rational Use of Lime.
No. 139. Tomato Diseases.[1]
No. 144. The Relation of Light to Greenhouse Culture.
No. 145. The Cost of Milk Production.
No. 148. On the Diagnosis of Infection with Bacterium Pullorum in the Domestic Fowl.[2]
No. 149. A Study of Variation in Apples.
No. 150. Reports on Experimental Work in Connection with Cranberries.
No. 151. The Determination of Acetyl Number.
No. 152. The Digestibility of Cattle Foods.
No. 153. A Summary of Meteorological Records for Twenty-five Years.
No. 154. Alfalfa.
No. 155. New Fertilizer Materials and By-products; and Cocoanut Meal.
Nos. 131, 135, 140. Inspection of Commercial Fertilizers for the Years 1909, 1910 and 1911.
Nos. 132, 136, 139, 142. Inspection of Commercial Feedstuffs for the Years 1909, 1910, 1911 and 1912.

Annual Reports.

Hatch Experiment Station: Fifth (1893); Sixth (1894); Tenth (1898); Eleventh (1899); Twelfth (1900); Thirteenth (1901); Fourteenth (1902); Fifteenth (1903); Sixteenth (1904); Seventeenth (1905).

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[1] Edition nearly exhausted.

[2] Bulletins 148–155 were not printed until after the end of the year covered by this report; but are here included, as the date of printing the report is later than the dates of printing these bulletins.

Massachusetts Agricultural Experiment Station: Twentieth (1908); Twenty-first, Part II. (1909); Twenty-second, Part I. (1910); Twenty-third, Part I. (1911); Twenty-fourth, Parts I. and II. (1912); Twenty-fifth, Part I. (1913).

Circulars.

No. 20. Lime in Massachusetts Agriculture.
No. 27. Seeding Mowings.
No. 29. Soil Analysis.
No. 36. Poultry Manures, their Treatment and Use.
No. 37. Green Manuring and Cover Crops.
No. 38. Cabbage, Cauliflower, Turnip, Rape and Other Crucifers.
No. 40. Downy Mildew of Cucumbers.
No. 41. The Control of Onion Smut.
No. 42. Fertilizers for Potatoes.
No. 43. Cut Worms.
Home Mixed Fertilizers.
Orchard Experiment.
Fertilizers for Corn.
Composition and Digestibility of Fodder Articles; Composition of Fertilizer Materials, Refuse Substances, Garden Crops and Soils. (A separate from the twenty-third annual report.)
For distribution in Massachusetts, Bulletin No. 180 of the Connecticut Agricultural Experiment Station: Studies on the Tobacco Crop of Connecticut, by Director E. H. Jenkins.

The plan followed in the distribution of our publications during the past year has been the same as for several years, and is described in the twenty-fourth annual report. The demand, however, has greatly increased and the size of editions must be correspondingly increased. The edition of a number of the bulletins has recently been entirely exhausted within a few weeks after publication, while requests for them will continue for months and even years. With the increase in interest in scientific agriculture and country life, with the multiplication of institutions in which agriculture is taught, and of those, both public and private, devoted to agricultural experiment and demonstration, with the fuller development of agricultural extension service under the recently enacted Lever bill, and the organization of the county league or agent system, is sure to come a yet more rapid growth in demand for station publications.

Thus far it has been the policy in this station, as it is in most, to send publications on request to citizens of other States. This is sound policy from the standpoint of publication efficiency, and fully justified by the fact that a large share of the funds for the support of our experiment stations comes from the federal treasury. The fullest reciprocity is desirable, for in most cases results obtained in one State find almost equal application in numerous others.

Still another cause of increased demand is found in connection with schools which teach agriculture, which, in not a few cases, make use of bulletins in their class work, for which purpose a large number of duplicate copies is often requested. It has thus far been our policy to meet this demand also when possible.

If we are to continue in the future the generous policy of the past, and to meet the increasing demands which have been referred to, it will become necessary either to greatly increase the expenditure for publication or to curtail circulation in certain directions. It is believed that the latter course can be followed without disadvantage to any real interest. A careful study of the situation as affected by the existing law governing the publication of our annual reports has led to the conclusion that there is wasteful circulation and some duplication, resulting from the inclusion of the formal technical parts of our reports in the annual reports of the secretary of our State Board of Agriculture; and a plan which shall at the same time avoid such waste and duplication and bring our method of publication into conformity with the plan recommended by the American Association of Agricultural Colleges and Experiment Stations has been embodied in an amended act which will be brought before the Legislature of 1914. The act as amended leaves the determination of the size of the editions, within a specified maximum, to the director, who will be able to adapt any edition to the prospective demand, which varies widely for different publications. The advantages of the act as amended are so clear that its passage is confidently looked for.[1]

A list of such of our publications as can still be sent on request will be found on page 7*a*.

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[1] This act was passed before the date of printing.

MAILING LISTS.

The fullest economy in the matter of the circulation of station publications is possible only when the mailing lists are kept fully alive. Very frequent revisions are necessary. It is true that the United States postal regulations state that postmasters must return all station publications not delivered, but in a very large proportion of cases this regulation is not complied with. It has been our practice, therefore, not only to make corrections whenever reported, and to drop names when publications are returned, but to fully revise all Massachusetts lists once in two years. Under these conditions the number of addresses which we find should be dropped because of death, removal or other causes is surprising. It must average about 20 to 25 per cent. of the total. There is also an astonishing number of changes shown to be necessary in every revision. These are due in many cases to removal, but in not a few instances to changes in post offices. It is estimated that in the last revision about one-half of the addresses remaining required change. There is much difference in the number for different post offices, a difference no doubt traceable to difference in the faithfulness with which the postal regulation above referred to is complied with. The table shows the nature of the lists which we at present maintain and the numbers in the several classes.

Residents of Massachusetts (general),	13,325
Residents of other States (general),	557
Residents of other States (general and technical),	765
Residents of foreign countries,	154
Newspapers,	513
Libraries,	343
Exchanges,	189
Cranberry growers,	1,710
Beekeepers,	3,719
Feed and fertilizer dealers,	310
Greenhouse growers,	1.848
Meteorological,	386
United States Department of Agriculture Official List,[1]	2,794
Total,	26,613

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[1] Publications are not as a rule sent to all on this list but only to presidents, directors, libraries and specialists likely to be interested.

The general list, as will be seen, includes 13,325 names. It is felt that sending all publications except those of a highly technical character (which we always give a much more restricted circulation) to all the persons on the list doubtless involves considerable waste. Our agriculture is highly specialized in many sections. Our publications on specialized branches of agriculture are of interest only to those engaged in them, and it is our policy to increase the number of special lists with a view to a better and more economical, and at the same time more effective, circulation of our various publications.

Extension Service.

The experiment station is still called upon for a large amount of service which is really of the character of extension. The extension service of the college, under Prof. W. D. Hurd, is now handling an enormous number of requests for information and advice; but the appreciation of and call for such assistance has grown with such rapidity that there has been no appreciable decrease in the number of calls upon the specialists of the station staff. Correspondence still makes heavy demands upon their time. They still accept many invitations for public lectures and demonstrations all over the State. It is the policy in the institution that this work shall be done mainly by members of the extension service staff. The specialists of the experiment station must naturally always be in demand for addresses on certain subjects, but since it is recognized that meeting many engagements of this character interferes greatly with research efficiency, such addresses should be restricted within narrow limits.

Needs of the Station.

Attention has been called to the fact that the gradual increase in the amount appropriated by the State for the support of the experiment station is not adequate; but as the act of the Legislature making provision for such increase was made with a fairly definite understanding that further increase would not be asked for within the period covered by the act, it would be contrary to sound policy to ask an increase in appropriation for general purposes. There are, however, two needs so pressing that they must be stated and should be provided for as soon as possible. These are additional land and an appropriation for demonstration on selected farms throughout the State.

Land. — The area available for experiment in the departments of agriculture and horticulture is far too small. There has been no increase for many years except by lease, a system which has numerous disadvantages which are referred to later. Meanwhile, the science of agriculture has gained rapidly. New discoveries constantly widen our horizon. Investigations are now needed in fields undreamed of not many years ago. Soil biology, soil physics, the influence of toxins, the theory of antagonism, are a few among the many fields in which work is urgently needed.

The station now leases four different areas for experiment, — two and one-half acres in Concord for work with asparagus, which has been held for seven years on an indefinite lease; six and one-half acres in South Amherst for orchard experiments, leased for ten years, seven of which have already passed; eighteen acres adjoining the station grounds in Amherst, leased for orchard experiments in 1912 for twenty years; and two acres, also in Amherst but not immediately adjoining the station grounds, which we have used for one year on a four-year lease.

In the case of the areas in Concord and South Amherst there has already been paid for the use of the land sums in each case considerably in excess of the figure at which these properties could have been purchased. The same will be true of one at least of the other areas mentioned within a very few years. The policy of leasing is not, therefore, a sound one from the standpoint of economy. There are, however, much more important objections, chief among which is the uncertainty of tenure for the full period during which the experiment should continue. This cannot be determined in advance. In the case of the South Amherst area it was thought when the lease was executed that the specific problem for which it was desired could be solved within the ten years, but it is already apparent that it would be a great advantage to continue the varying fertilizer and cultural treatments during a much longer period, in order to determine more fully the ultimate effects upon the apple, which is a very long-lived tree. We already know that the present owner (who has purchased the property since we hired it) will not renew at any figure which the station can afford to pay. We shall find ourselves, therefore, three years hence, compelled to turn over to the owner a piece of property worth several times what it was when we leased it, having meanwhile paid the former owner and to the present one a total sum considerably in excess of the value when the land came under our management.

The situation as affecting the Concord land, planted to asparagus (also a long-lived crop), is from a business point of view entirely similar; but as the lease of this land is indeterminate it is yet worse from an experimental viewpoint, for the owner may terminate the lease at any time. Fortunately, such action on his part is not now anticipated, for he is very greatly interested in the experiment; but we are entirely dependent upon his good will.

Another point to be considered is that the value of areas suitable for our needs is steadily appreciating. Land can probably never be bought at lower prices than now. It would seem the part of wisdom to take early action.

Not only do sound business considerations urge this course, but the need becomes every year more desperate as the area which has been available for station use is more and more encroached upon as the result of the growth of the educational side of the institution. The location of buildings has already rendered far less valuable or entirely valueless for our use three fields in which important lines of inquiry were in progress, and other locations which will have a similar effect are in prospect.

Still another point has an important relation to our need. With the great increase in the number of students who room in all parts of the town, and with the erection of new buildings in different parts of the campus between which large numbers of students must pass in going to and from classes, it has become almost impossible to prevent trespass, as a student in a hurry is disposed to cut corners, which means crossing the plots. It seems to the director, and to all members of the station staff familiar with the situation, and especially to those directly interested in the use of land, that a candid consideration of the facts stated, and of others which might be presented, leads inevitably to the conclusion that more land should be purchased at the earliest possible moment.

Demonstration. — There are two rather distinct types of demonstration: the one having for its object teaching a lesson concerning the value of a line of practice, already fully established as sound, for the purpose of impressing the farmers in the locality in which it is located with the fact of its importance to them; the other designed to test the validity of results of research or experiment in our own or other stations under varying conditions affecting soil, local climate and economic result upon the farms in different sections of the State.

Demonstration of the first kind is properly the function of the extension service; that of the second kind is more legitimately the work of the experiment station. for it is experimental in nature and will result in broadening the field of knowledge. New and more or less untried methods or modifications of old methods, new crops or varieties, new insecticides and fungicides, new fertilizers, or new methods of employing fertilizers, are a few among many subjects which may appropriately be made matters for station demonstration.

There is one line of experimental demonstration in particular which is urgent, both because of its vital importance in the agriculture of the State and because the station has been strongly urged to undertake it. I refer to methods of pasture improvement. The experiment station has obtained some very striking results in the use of fertilizers. It is important that the extent to which similar results may be anticipated on different types of soil be investigated; and that the question as to whether pasture improvement by such use of fertilizer or by other methods which are in need of investigation can be made profitable. The pastures of the State stand in great need of improvement. Our live stock ranges over wide areas to obtain, in too many cases, only a scanty subsistence. The production of milk in the State has rapidly fallen off during recent years, no doubt in considerable measure because of the poor condition of our pastures.

Moreover, the high prices now ruling for meats make it seem highly probable that the time has come when, with intelligent improvement of pastures, the State might wisely produce a much larger share of the meat consumed by its inhabitants. It seems entirely possible that steers and sheep can be profitably fattened in the State even if they can be reared to the fattening age more cheaply in other parts of the country. There is, however, a question whether even the production of well-bred stock to the fattening age may not be successfully carried on. Our soils and climate are admirably adapted to the production of pasture forage. An appropriation for the purpose of undertaking extensive demonstration experiments in pasture improvement is highly desirable.

The Attitude of the Station toward Private Work.

That the most important function of the experiment station is the public service is generally recognized. It is also generally recognized that its principal work should be investigation, with a view to gaining new knowledge of fundamental laws and principles bearing upon the art of agriculture, and experiment, which has for its object the discovery of new applications of known laws and principles and better methods, both in the practice and business transactions of the farm and garden. The results of its investigations must of course be published and disseminated. In addition, this experiment station is charged with the execution of important control laws, — those relating to the manufacture and sale of commercial fertilizers and commercial feedstuffs, and the dairy law.

The cost of the work connected with the execution of these laws is covered by funds especially provided therefor. It makes no draft upon the funds appropriated for investigation, and the work is in the hands of a special staff which would not otherwise be employed. This work, therefore, does not lessen station capacity for investigation and experiment. On the other hand, as has been pointed out under the topic "Maintenance," since unexpended balances are available for certain kinds of experiment, our resources for investigation are somewhat increased because of the fact that the station is charged with the execution of these laws.

There are, however, constant and insistent requests for services which lie outside of the fields which have been designated, many of which are more or less private in character. To meet these requests would consume a large share of the time and energy of the members of our staff, and must greatly lessen their capacity for research. Not a few of these services are routine in nature, the same service is requested over and over again by different individuals, the results often have a transient value only, and it may be only to the individual requesting it. To use public funds for private work, especially in view of the fact that the public service must suffer if it is undertaken, would clearly be a mistake in policy.

Having thus endeavored to make the underlying principle and its reasonableness clear, a statement in detail of our attitude in relation to some of the kinds of service most frequently called for, with the special reasons therefor, seems desirable.

Chemical Analyses for Individuals. — Numerous requests for chemical analyses come to the station annually from individuals. There is hardly a substance of any possible interest to our citizens which we are not yearly asked to analyze. Soils, fertilizers, feeds, drinking waters, milk and cream, vinegar, drugs, minerals, and the viscera of animals supposed to have been poisoned are some of those most frequently sent in. Not a few individuals appear to regard such work as a proper function of the experiment station; occasionally one represents that as he is a taxpayer he has a right to such service, overlooking the fact that taxes are assessed to support public work, not to pay for private service. The majority, on having their attention called to the distinction referred to, take a correct view of the matter.

Many offer to pay the costs of analysis. The station is not organized for commercial work. Such work would almost inevitably interfere with more legitimate work, unless, indeed, a staff of chemists who should be employed in commercial work only should be maintained. This policy cannot at present be carried out. It would require separate laboratories, and it is not sufficiently constant to afford regular employment. Fortunately, there is little occasion for the establishment of a State laboratory for commercial work as there are numerous and reliable private commercial chemists. Further, there will be general agreement that for a State institution to engage in commercial work would be an unwise intrusion in a field where the rights of private enterprise would be infringed. The station, as a rule, does not (drinking waters excepted) accept compensation for any chemical analyses which it may undertake.

Analyses of Fertilizers or Feeds for Manufacturers or Dealers. — Under no circumstances can the station undertake chemical analysis as one of the necessary steps for manufacture or as a basis for guarantees. It should not and will not assume this responsibility.

Analyses of Fertilizers and Feeds for Consumers. — Not infrequently buyers send in samples, with the request that we determine the composition. It is contrary to sound policy, as a rule, to make such analyses, for two reasons: —

1. The materials in almost all cases are sampled in the course of the regular inspection and analyzed. A repetition is uncalled for.

2. It is not certain that these samples are properly taken, for to secure a thoroughly representative sample requires special instruction and experience. No suit nor claim for shortage can be based upon an analysis of a sample not officially taken.

In all cases, however, where either fertilizers or feeds are purchased on guarantee, with a definite understanding that the price shall be determined on the basis of analysis, the station is prepared to sample the goods where the transaction is of sufficient magnitude to warrant the expense, and will make the required analysis. Further, in the case of feeds it is sometimes possible, by mechanical separation and examination under low magnifying power (processes which can quite easily be carried out), to determine the ingredients, and such work the station will do on request.

Analyses of Soils. — The number of letters received asking for instruction in relation to sending samples of soil to be analyzed for the purpose of determining what fertilizers should be used, and the number of samples of soils sent in for such analysis for that purpose without previous inquiry, is constantly increasing. For this reason, although this matter is somewhat fully discussed in the twenty-first annual report, it seems necessary to refer to it again. There is widespread misapprehension as to the value of the chemical analysis of soils. It seems to be very generally believed: —

1. That chemical analysis will show to what crop a soil is suited.

2. That such analysis will determine what fertilizer should be applied and the quantities needed.

It seems also to be generally believed that the cause of crop disease will be revealed by a chemical analysis of the soil in which the crop is growing.

None of these views is justified by the facts. While the chemical condition of a soil is not altogether without influence in determining the crops to which it is suited, crop adaptation, at least within such range of soil variation as exists in this State, is determined in far greater degree by physical and drainage conditions. Neither does the chemical analysis of the soil show what fertilizers should be applied. Such analysis will determine with exactness the proportion of the several elements present, but it cannot show to what extent these elements are available; indeed, there is no such thing as a constant ratio of availability. The capacity of different crops to extract food from one and the same soil varies widely, and fertilizer requirements are determined in far greater degree by crop than by condition of the soil, within such limits of variation as are usually found in the soils of this State.

Occasionally a faulty chemical condition is responsible for an abnormal or unhealthy condition of the crop, but in most cases the immediately active cause of plant disease is the presence of a parasitic fungus, and this fungus is usually capable of fixing itself upon the plant, whatever may be the composition of the soil.

For the reasons briefly stated the chemical analysis of soils does not, as a rule, afford results which have a value commensurate with the cost, and this station will not, therefore, make such analysis unless a soil differs widely from the normal in natural characteristics, or has been subjected to unusual treatment of such a nature as to probably greatly influence its chemical condition.

In this connection attention is called to the fact that the most satisfactory means of determining the fertilizer requirements of crops is by carrying out a simple but carefully planned experiment in the field; and in all cases the station is glad to advise in relation to such experiments. It will furnish plans on application, provided the general conditions and the crops to be grown are indicated.

Water Analyses. — Properly taken samples of drinking water will be given a sanitary analysis, for which a uniform charge of $3 is made. This charge hardly equals cost. It is much below the usual figure for such work, which probably averages at least $10. A small charge was found to be necessary in order to prevent the indiscriminate forwarding of samples in such number as to constitute a serious burden, and in many cases when conditions hardly suggested any necessity for such analysis.

Analyses of Milk and Cream. — For the present, as has been our practice for some years, the station will analyze properly taken and preserved samples of milk and cream for fat and total solids, free of cost. This is done because facilities for such work are seldom within the reach of farmers, in order that it may be more fully recognized that the value of the product is not determined solely by the number of quarts or pounds of milk produced.

Foods and Drug Analyses. — This experiment station does not, under any conditions, undertake analyses of foods or drugs. It is not charged with the execution of the pure food law. That work in this State is looked after by the State Board of Health.

Personal Inspection of Farms or Lands. — Quite frequently a letter is received asking the station to send some one for the purpose of looking over a farm and advising in relation to its value or management, or for the examination of a certain tract of land, perhaps with reference to the possibility of its improvement, or for the purpose of determining what crops it is suited to. The station organization does not at present include men whose time is free for work of this description. Such work, moreover, is private in its nature; it is in the interest of individuals and not in the interest of the public; and it is doubtful whether, therefore, it is a proper function of the experiment station. Special trips for the examination of farms or tracts of land will not, therefore, be undertaken. We do constantly advise in relation to farm problems which are clearly and definitely brought before us, and members of the station staff make many visits to farms, orchards, gardens and hothouses for the study of important problems when the solution is likely to be of public as well as of private interest.

Station Literature. — It appears to be generally thought that the station is prepared to furnish comprehensive manuals on all subjects related to rural life. We constantly receive requests which begin: "Please send me your book, or your treatise, on   ," and such subjects as potatoes, corn, strawberries, asparagus, cranberry culture, soils, drainage, etc. follow. The preparation of such manuals involves compilation rather than investigation. It is the latter for which the station is maintained. If distribution of such manuals is a proper function of any branch of an agricultural college it is that of the extension department rather than of the station. The station is not a publishing house. It is true that in connection with the report of the results of investigations it sometimes seems best to outline existing conditions, practices and opinions. In so far as this assists in correlating new results with earlier practice it is legitimate in a station publication, and some of our publications, therefore, may be valuable as a fairly comprehensive general guide to practice, but funds placed at the disposal of the station for investigation should not be, and are not, used for the preparation of exhaustive manuals.

CONTROL WORK.

No change has been made in either of the control laws with the execution of which the experiment station is charged. The regular inspections of fertilizers, feeds and dairy apparatus have been carried out without incidents requiring special mention. The amount of this work steadily increases, especially in connection with fertilizers and feeds, with the multiplication of brands. The comparative number of official samples for the past few years clearly shows this growth.

Number of Official Samples.

YEAR.	FERTILIZERS.		FEEDS.	
	Brands.	Samples.	Brands.	Samples.
1909,	458	1,052	196	895
1910,	487	890	195	946
1911,	519	1,063	204	1,055
1912,	527	1,180	194	902
1913,	571	1,299	227	1,115

The table shows the number of brands of complete fertilizers and agricultural chemicals sampled in the State during each of the years since 1909. In that year the total number was 458; in 1913 it had grown to 571. In the latter year the number of brands of potato fertilizers offered for sale in the State was no less than 90. It is not easy to say, since registration has only recently been required, how many kinds of feed mixtures are offered for sale in the State, but the number is clearly very large. This matter is referred to for the reason that there can be no question that the continued multiplication of brands of fertilizers and feed mixtures increases the cost to the consumer, who in the last analysis must pay the costs of advertising, agencies, analyses, etc. The greater the number of kinds the greater these costs, and therefore, unless the kinds so differ from each other that each fills some special need or requirement which no other could fill equally well, this constant multiplication of kinds is to be deprecated. There are without doubt many more kinds, both of fertilizers and feeds, offered in our markets than are needed. No one will attempt to maintain for a moment that we need ninety kinds of potato fertilizers, nor is it possible that we need nearly six hundred different brands of fertilizers or over two hundred kinds of feeds. A reduction in the number would be a distinct advantage, both to manufacturers and dealers on the one hand and to consumers on the other.

Detailed reports on the control work will be found in the report of the chemist, Dr. J. B. Lindsey.

LINES OF WORK.

The lines of experiment and research followed for the past few years, and referred to in recent reports, have been continued. One new research problem has been taken up. This is in the poultry department. Provision for a breeding house was made by legislative appropriation in 1912, and with the coming of Dr. Goodale in February a study of some of the more important problems connected with the inheritance of such charcteristics as fertility, hatchability and fecundity was begun.

Another new line of inquiry has been undertaken during the year. This was made possible only by the rental of land for the purpose. The work in view is to determine by most careful experiment the rate of availability of the phosphoric acid of basic slag meal. The experiment is part of a plan recommended by the committee appointed by the Association of Official Agricultural Chemists. Thirteen other experiment stations are co-operating. This work is in direct charge of our fertilizer chemist, H. D. Haskins.

General Experiments.

An idea of the general work may be gained from the following enumeration of the principal lines of inquiry. These are: —

Soil tests with fertilizers with different crops in rotation; comparison of different materials available as sources, respectively, of nitrogen, phosphoric acid and potash for both field and garden crops, with a view to determining the ultimate effects of each on soil chemistry, biology and physics; results of the use of different forms of lime; systems of fertilizing mowings and orchards; trial of different manures and fertilizers for both tree and bush fruits; methods of applying manures;

variety tests of garden and field crops and of fruits; tests of different spray materials; comparison of methods of pruning; comparison of cover crops in orchard management; tests of southern *versus* northern nursery stock; of one and two year old apple trees; tests of trees pruned and not pruned at setting time; trials of new crops; determinations of the digestibility of feedstuffs; methods of feeding for milk; systems of feeding and management of poultry for eggs; tests of the efficacy of anti-hog cholera serum; studies upon the diagnosis and transmission of avian tuberculosis; co-operation with selected farmers in the trial of crops and systems of fertilizing them.

We have two substations, one for investigations connected with asparagus at Concord, the other for cranberry investigations in Wareham. Brief references to the work at these stations will be found later in this report.

Research.

The research problems under investigation are for the most part supported by the Adams fund, and have received the approval of the Office of Experiment Stations. The principal problems at present under investigation are the following: —

1. To determine the principles which should underlie practice in the use of fertilizers for the cranberry crop.
2. To determine the principles which should underlie practice in the use of fertilizers for asparagus.
3. Work in plant breeding in the endeavor to produce more rust-resistant types of asparagus. (In co-operation with the Bureau of Plant Industry, United States Department of Agriculture.)
4. Investigation of the solubility effect of ammonium sulfate on the soil of one of our experimental fields (Field A).
5. The effect of food on the composition of milk and butter fat and on the consistency or body of butter.
6. The cause of the digestion depression produced by molasses.
7. Why insecticides burn foliage.
8. Effects of meteorological conditions on the development of plants and crops, both in health and disease.

9. Influence of soil moisture on seed germination.

10. Relation of light to burning from spraying with fungicides and insecticides.

11. Nature and cause of burning from fumigation with various gases.

12. Effects of electricity on nitrogen fixation in soils and in stimulating plants in general.

13. Relation of light to burning of vegetation from miscible oils.

14. Study of interrelation of stock and scion in apples.

15. Plant breeding, especially with peas, beans and squashes, to determine the extent to which the Mendelian laws appear to govern heredity.

16. The relation of climate to variation in leading varieties of apples.

17. The economic importance of digger wasps in relation to agriculture.

18. Color vision in bees.

19. The diagnosis of white diarrhœa in adult fowls.

THE ASPARAGUS SUBSTATION, CONCORD.

The year 1913 at the Asparagus Substation in Concord was highly successful from the experimental point of view. Mr. Prescott continued his effective service in general local charge, and Mr. J. B. Norton of the United States Department of Agriculture, his enthusiastic breeding work. It will be remembered that the experiments at this substation are in two distinct lines: a study of the plant-food requirements of the crop and, second, breeding experiments with a view to the production of a rust-resistant type.

Plant-food Requirements.

The crop on the plots where the fertilizer experiments are located was the best produced in their history. The average yield per plot in 1912 was 278.5 pounds; in 1913 it was 374.9 pounds. The rate of yield per acre in 1912, 5,570 pounds; in 1913, 7,498 pounds. The average yield per plot in 1913 was, therefore, about 100 pounds greater than in 1912; the rate per acre in round numbers, one ton greater in 1913 than in 1912. The larger yields in 1913 were doubtless due in considerable measure to the fact that there was but little rust in 1912. It is thought that the specific effects of the different fertilizer elements and combinations, therefore, are shown much more clearly in the yields obtained in 1913 than in any previous year. It is not the purpose at this time to report either the plan of the experiment or the results in detail; but the following general conclusions appear to be warranted:

A fairly liberal use of chemical fertilizers is as effective to date in increasing yield as a combination of manure and fertilizers.

Effect of Nitrate of Soda as a Source of Nitrogen. Nitrate in Connection with Mineral Fertilizers (*Acid Phosphate and Muriate of Potash*). — Nitrate of soda greatly increases the crop, but a quantity in excess of the rate of 300 pounds per acre has not so far seemed to be beneficial, and in a considerable number of instances the minimum application (at the rate of 200 pounds per acre) has given a crop as good or even slightly better than any larger amount.

Season of Application of Nitrate. — Nitrate of soda in these experiments is applied in equal amounts in three different methods as regards season: —

(*a*) All in the early spring.

(*b*) Half in the early spring and half after the cutting season is ended.

(*c*) All after the cutting season is ended.

The results indicate a moderate degree of superiority for a method of application in which a portion at least of the nitrate is applied after the cutting season. This superiority shows itself both in slightly larger yield and in apparently making the crop somewhat more resistant to rust.

Nitrate in Connection with Manure. — In the case of all plots top-dressed with manure at the rate of 20,000 pounds to the acre the application of nitrate also has resulted in a distinct gain in yield, which, however, reaches its maximum on the medium quantity of nitrate (300 pounds per acre).

When nitrate is used in connection with manure (as in the other combinations referred to) summer application or divided spring and summer application gives results rather better than spring application.

Complete Chemical Fertilizers in Connection with Manure. — A mixture of chemicals, making what may be called a complete fertilizer (nitrate of soda, acid phosphate and muriate of potash), used in connection with manure at the rate of 20,000 pounds per acre, produced a moderate increase in crop, but the increase produced has not been as great as that produced by the use of nitrate alone in connection with the same amount of manure. The fact that the increase on the complete fertilizer is less than that produced by nitrate alone is probably not significant; but since it is no greater, the conclusion is apparently justified that the use of the acid phosphate and muriate of potash in connection with manure has not been beneficial.

Effect of Acid Phosphate. — The addition of acid phosphate to a combination of nitrate of soda and muriate of potash, furnishing adequate quantities of nitrogen and potash, has but little effect upon the crop.

Effect of Potash. — The use of muriate of potash in connection with a mixture composed of nitrate of soda and acid phosphate in adequate amounts greatly increases the crop, but a quantity in excess of 300 pounds to the acre has not been beneficial.

Comparison of Different Materials as a Source of Potash. — Muriate of potash is used in these experiments as the source of potash on almost all plots, but for the purpose of comparison one plot for each is introduced where the source of potash is different. The materials under comparison are wood ashes, kainit, high-grade sulfate of potash and low-grade sulfate of potash (potash-magnesia sulfate). The yield on all of these materials is considerably less than on the muriate of potash, but the kainit is considerably superior to the ashes or either of the sulfates. It is important, however, to call attention to the fact that it seems likely that the yield on the plots receiving ashes and the sulfates of potash is slightly decreased by the neighborhood of an oak tree, which stands about two rods distant from one end of the field.

General Conclusion. — The general conclusion is at least strongly suggested that in common practice among the asparagus growers of the State chemicals are frequently used in quantities in excess of those which are required to produce maximum crops.

BREEDING EXPERIMENTS.

The new types of asparagus produced by the crosses made by Professor Norton, and referred to in previous reports, have not been subjected to tests as severe as Professor Norton has desired during the past two years since rust has been less prevalent than usual. So far as can be judged, however, the best rust-resistant types fully retain their valuable characteristics. Numerous other crosses which are promising have been made.

We have experienced great difficulty in our efforts to produce seed from the more desirable breedings, owing to the ravages of the asparagus beetle (*Crioceris 12-punctata*), which preys both on foliage and directly upon the berries. Thus far no thoroughly satisfactory method of protection has been discovered. This fact will necessarily make the time when we shall be ready to distribute seed for trial later than we had hoped, and we are unable at present to announce when such distribution will be possible, nor can we state the basis on which any distribution will be made. Clearly, however, the new types must be so handled as to insure the multiplication of those which seem most desirable as rapidly as possible in order that they may be available at an early day for test under a wide diversity of conditions.

CRANBERRY SUBSTATION, WAREHAM.

A full report on the experimental work of the past year will be found in Bulletin 150 (Part II., page 37), which is a part of this annual report. Bulletin 150 also contains a paper by Professor Morse on the composition of bog waters (Part II., page 62).

The bog produced a very superior crop in 1913, both as to quantity and quality of the fruit. The accounts are so kept as to make it possible to distinguish between such expenses as would be required in ordinary bog management and such as are incurred in connection with the experiments in progress. The area of the bog is, in round numbers, twelve and one-half acres. The two financial statements follow: —

Bog Account.

Maintenance: —		
Tools and similar equipment bought or repaired,	$94 29	
Oil for engines, etc. (gasoline, kerosene and lubricating),	96 09	
Engine and bog pump repairs,	173 95	
Pumping labor,	84 10	
Bees, rental of,	6 00	
Mowing of upland,	57 35	
Weeding,	26 50	
Fertilizers,	49 20	
Mending dikes,	3 50	
Digging out ditches,	14 00	
Repairs to buildings,	1 95	
Lumber,	7 96	
Sundries,	27 10	
Miscellaneous labor,	50 15	
Raking vines after picking,	31 72	
		$723 86
Harvesting: —		
Picking,	$500 46	
Separating,	131 69	
Screening,	119 08	
Packing,	45 75	
Carting,	132 65	
Packing materials (barrels and coopering),	538 75	
		1,468 38
Contingent expenses,		3 38
Improvements: —		
Building roads,		42 40
Total,		$2,238 02

Experimental Account.

Experimental: —		
Labor,	$422 42	
Supplies and apparatus,	279 23	
Spraying materials,	10 10	
Fertilizers,	9 37	
		$721 12
Stationery and postage,		43 95
Traveling,		35 22
Contingent: —		
Freight,	$8 02	
Express,	7 15	
Surveying,	5 00	
Carting,	14 40	
Telephone,	27 11	
Painting,	9 50	
Lumber,	18 75	
Incidentals,	1 92	
Carpentering,	4 12	
		95 97
Furnishings,		1 25
Total,		$897 51

The total sales for the year were as follows: —

Fruit,	$6,667 22
Vines,	19 65
	$6,686 87

The total receipts for products sold amounted to $6,686.87. The total ordinary bog expenses were $2,238.02. Receipts for products sold, therefore, exceeded ordinary expenses to the amount of $4,448.85. It will be seen that the bog during the year has furnished a large surplus, available to help cover the costs of experimental work. The total experimental expenses shown in the above table amount to a little less than $900, but this, it should be pointed out, does not include the salary of the superintendent. Even with this included the bog during the past year is somewhat more than self-supporting, but attention is here called to the fact that cranberry bogs show a marked tendency to heavy fruit production in alternate years only. The product of 1912 sold for $1,069.87. If the two years, 1912 and 1913, then be included, the bog does not produce sufficient income to cover both ordinary and experimental expenses, and it can hardly be anticipated that over a series of years it will do this, although undoubtedly it will carry a considerable share of such expenses unless the scope of our work be greatly increased, as compared with that at present carried on.

During the past year Dr. Franklin has continued to co-operate with the United States Weather Bureau at Boston in weather observations, with a view to collecting data which shall be useful in forecasting frosts. He believes that substantial improvement has been made. At the same time important experiments on methods for frost protection have been in progress. The Skinner system of sprinkling has been tested, with unfavorable results. Other methods are suggested, among them protection from the early morning sun by smoke or some other screen, which method, however, has not been fully tested.

The value of keeping a bog well sanded as a means of frost protection is pointed out.

Co-operative work with the United States Department of Agriculture, which is represented in such work by Dr. Shear, has been continued. The results do not clearly indicate that the systems of spraying which were tried were efficacious.

Copper sulfate in different proportions in the flowage water has been tested as a fungicide. The results were not favorable.

Preliminary work looking toward the possible development of varieties superior to those now generally cultivated has been begun, — a line of work which should prove of much value.

The relation of insects, especially the honey bee, to the pollination of the flowers has been further studied, the results fully confirming those previously obtained. The cranberry appears to be dependent upon transfer of pollen by insects, and the honey bee is undoubtedly one of the most important among such insects.

Fertilizer experiments were continued, the application of materials being deferred until July 15, with a view to avoiding the possible loss through reflowage, which it was believed might be necessary up to that date for protection from insects or frosts. There was no increase in crop as a result of the application of any of the fertilizers; indeed, the fertilized plots gave somewhat smaller yields than the unfertilized. Whether this was due to the lateness of the application is uncertain. The result is, however, the opposite to that which was obtained in 1912.

A large part of the work of Dr. Franklin has consisted in further study of the various insects which affect the crop. The observations made and the results obtained are fully set forth in Dr. Franklin's report. Among the more important conclusions which appear to be justified are the following: —

Careful observations have been made on a span worm (*Epelis truncataria* var. *faxonii* Minot). The pupæ are not destroyed by winter flowage. Heavy sanding kills most of them. In cases of very heavy infestation burning over the bog may be the best course to take in order to get rid of the insect.

Observations and further experiments on the flowed bog fireworm (*Rhopobota vacciniana* (Pack.)) indicate that late holding of the winter flowage (until about June 1), and reflowing about three weeks later, is an effective means of destroying this insect. Spraying with arsenates is also useful, but whether arsenate of lead or Paris green should be preferred is not yet certain, although it is believed that the arsenate of lead is the better of the two. There appears to be a considerable difference in the extent to which different varieties are attacked by this insect, the Late Howe being much more seriously injured than the Early Black.

A number of important parasites of the fruit worm (*Mineola vaccinii* (Riley)) have been discovered and studied. The most important among them appears to be *Phanerotoma tibialis*. Just how important this will prove to be in helping to control the fruit worm is not yet clear. Observations indicate that parasites are much more abundant on dry bogs than on those which are flowed.

Flowage experiments indicate that fall flowage, whatever the depth, is not effective in destroying the fruit worm. Experiments on dry bogs indicate that resanding is not an effective method, and the suggestion is made that in case of very heavy infestation the destruction of all the bloom by spraying with a solution of iron sulfate will be an effective means of starving out this insect in a bog so treated.

Experiments on weed destruction by spraying with iron sulfate indicate that a 20 per cent. solution is fairly effective in killing the tops of horsetail (*Equisetum*), but the roots were not killed; and Dr. Franklin is not ready to recommend repeated use of such a solution, as it is possible that in large amounts it will prove injurious to the cranberry itself.

Copper sulfate dissolved at the rate of 1 pound to 25 gallons of water injected into holes in the bogs proves ineffective.

Careful observations upon the fruit produced by plots respectively untreated and resanded indicated that resanding injures keeping quality.

Professor Morse's work in the study of the water from cranberry bogs indicates that the composition of this water was not affected to an appreciable extent by the varying fertilizer treatment of the different bogs. His observations further indicate that vine growth is affected in greater degree by varying drainage conditions than by variation in fertilizer applied. The greatest vine growth was obtained in the bogs through which the water moved with greatest freedom.

INVESTIGATION.

In the agricultural department of the experiment station the lines of experimental work pursued have been similar to those followed for the last few years, but supplemented more and more fully by correlated chemical studies. In this work the usual number of field and closed plots has been employed. The number of pot experiments has been less than usual, owing to the absence of the director during the early part of the year. Attention will be here called to a few only of the results which seem most fully established.

High-grade sulfate of potash combined with bone meal continues to show itself superior to muriate in the same combination for alfalfa, raspberries, blackberries and rhubarb. The rates of yield per acre for these crops on the two potash salts under comparison during 1913 were as follows: —

	Muriate of Potash.	Sulfate of Potash.
Rhubarb (pounds),	17,913	24,174
Blackberries (pounds),	6,162	8,263
Raspberries (pounds),	2,068	2,683
Alfalfa (tons),	3.7	4.2

Muriate of potash, on the other hand, gives much larger yields of asparagus than the sulfate, both being used with equal quantities of bone meal. The rates of yield per acre are as follows: —

	Muriate of Potash.	Sulfate of Potash.
Asparagus (pounds),	6,927	6,007

The combination of low-grade sulfate of potash with bone meal continues to give larger yields of apples than muriate in such quantities as to furnish equal potash in the same combination. The yield of apples under the different fertilizer treatments in the season of 1913, and the total yields to date, are shown in the following table: —

Yield of Apples (Pounds).

	Plot 1, Manure.	Plot 2, Ashes.	Plot 3, Nothing.	Plot 4, Muriate of Potash and Bone.	Plot 5, Sulfate of Potash and Bone.
1913,	7,977	4,954.5	3,032	6,233	7,992
Totals to date,	41,547	25,226.0	10,148	23,360	34,663

As in previous years the three Gravenstein trees in the sulfate of potash plot gave a smaller yield in 1913 than the three Gravenstein trees in the muriate of potash plot, a result perhaps due to the proximity of the trees in the sulfate of potash plot to a neighboring forest.

Some fire blight showed itself in this orchard during the past season. The several plots in severity of blight injury ranked in the following order: 4, 5, 1, 2, 3. The Greening variety showed more blight than any other in all the plots except No. 5, in which the Gravenstein showed rather more than the Greening.

In the south soil test, where each plot has been continuously fertilized in the same way for twenty-five years, the crop in 1913 being corn, muriate of potash showed itself to be much superior to either nitrate of soda or acid phosphate in its effect upon that crop. The average rates of yield per acre on the nothing plots were: —

	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Nothing plots,	2.2	7.9	1,870

The rates of yield on the different fertilizer combinations were as follows: —

	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Nitrate of soda alone,	7.7	14.9	2,420
Dissolved boneblack alone,	1.3	9.7	2,180
Muriate of potash alone,	44.9	7.7	4,360
Nitrate of soda and muriate of potash,	46.9	4.3	3,500
Dissolved boneblack and muriate of potash,	44.6	5.1	4,040
Nitrate of soda, dissolved boneblack and muriate of potash,	40 0	4.4	3,840

It will be noted that only where potash is used is there any considerable increase in the crop.

In the north corn acre the fertilizer combination richer in potash gives a rather higher yield of hay than the combination relatively low in potash and high in phosphoric acid, which is similar in composition to the average of the corn fertilizers offered in our markets. This is the twenty-third year of this experiment.

On the south corn acre manure alone at the rate of 6 cords per acre gives about 600 pounds more hay than the combination of 4 cords of manure and 160 pounds of high-grade sulfate of potash. This is the twenty-fourth year of this experiment.

In the experiment comparing different phosphates used in such quantities as to furnish equal phosphoric acid, which has been in progress since 1897, the crop this year was corn. The apparent effects of the different phosphates upon the crop are shown in the following table: —

	Gain or Loss.	
	Corn (Bushels).	Stover (Pounds).
Plot 1, no phosphate,	-	-
Plot 2, Arkansas rock phosphate,	—1.9	+240
Plot 3, South Carolina rock phosphate,	—2.2	+720
Plot 4, Florida soft phosphate,	—0.2	+720
Plot 5, basic slag meal,	+6.1	+736
Plot 6, Tennessee rock phosphate,	+1.9	+720
Plot 7, no phosphate,	-	-
Plot 8, dissolved boneblack,	+3.5	+720
Plot 9, raw bone,	+7.3	+1,160
Plot 10, dissolved bone meal,	+14.3	+920
Plot 11, steamed bone,	+15.2	+1,240
Plot 12, acid phosphate,	+10.6	+1,320
Plot 13, no phosphate,	-	-

It will be noted that the effect of the untreated rock phosphates upon the yield of grain is extremely small, there being in most cases a slight decrease. On the other hand, the bone meal, both raw and steamed, the basic slag and the superphosphates (dissolved boneblack, dissolved bone meal and acid phosphate) all give moderate increases. There is an increase in stover in all cases, but materially smaller on the untreated rock phosphates than on most of the others.

The crop of grain was undoubtedly smaller than it otherwise would have been because of the effects of the heavy frost which came just before the middle of September, at which time the ears were not mature. This frost killed the leaves of the plants and the outer husks of the ears, but did not entirely check their development. There was, however, a large proportion of soft corn. The proportion of soft corn on the basic slag meal was least, and in general less on the soluble than on the more insoluble phosphates. The effect of the fertilizer, however, is undoubtedly somewhat obscured by the fact that there is a gradual increase in the proportion of clay in the soil from plot 1 toward plot 13. This difference makes the soil colder at the end of the field, where the more soluble phosphates were used, than at the other end, and this condition undoubtedly tended to increase the proportion of immature corn.

The percentage of soft or immature corn as compared with sound corn on the several plots is shown below: —

Percentage of Soft Corn as compared with Sound.

Plot 1, no phosphate,	48
Plot 2, Arkansas rock phosphate,	66
Plot 3, South Carolina rock phosphate,	87
Plot 4, Florida soft phosphate,	48
Plot 5, basic slag meal,	30
Plot 6, Tennessee rock phosphate,	51
Plot 7, no phosphate,	84
Plot 8, dissolved boneblack,	86
Plot 9, raw bone,	58
Plot 10, dissolved bone meal,	44
Plot 11, steamed bone,	52
Plot 12, acid phosphate,	67
Plot 13, no phosphate,	80

In the experiment in top-dressing mowings with different materials used in rotation since 1895 the crop was much below the average on account of the great deficiency in rainfall, especially during the latter part of the season. The rates per acre were as follows: —

	Hay (Pounds).	Rowen (Pounds).
Plot 1, bone and potash,	4,117	963
Plot 2, slag and potash (in place of ashes used in earlier years),	3,604	710
Plot 3, manure,	3,522	720

In this field two different seed mixtures, referred to in previous reports respectively as the "fescue mixture" and the "timothy mixture," are under comparison. The "fescue mixture," as has been true for the past few years, gave a considerably larger crop than the "timothy mixture."

The chemical department during the past year has published one bulletin, "The Record of the Station Herd and the Cost of Milk Production." This shows that the larger cows produce milk at lower cost than the smaller, and the conclusion drawn from the records (which are exact as regards food consumed and milk yield, but necessarily estimated as regards labor and some other items) is that milk of satisfactory quality can probably not be produced and sold at the farm at a profit at less than from 5 to 5½ cents per quart.

The chemical department has published a bulletin, "The Digestibility of Cattle Foods," found later in this report. In this will be found the results obtained in a large number of digestion experiments.

The chemical department has continued the study of the effects of food on the composition of milk. In this connection it has been found necessary, for accurate determination of the chemical composition of butter fats, to discover and perfect new methods and apparatus. A bulletin, "The Determination of the Acetyl Number," found later in this report, describes one of the improved methods. Some new forms of apparatus and other methods now under trial are highly promising and will be described in later papers.

The study of the composition of asparagus shoots and tops at successive stages of growth has been continued in connection with our study of the nutrition of this plant. Up to the present time no clear relation between fertilizer treatment and composition has been proved.

Cranberry nutrition studies have been continued, the composition of the waters of the small artificial bogs established at the station receiving particular attention. A paper on this subject will be found in a bulletin in later pages, "Reports on Experimental Work in Connection with Cranberries."

In the continued study of the effects of sulfate of ammonia on the soil it has been found that its use as a fertilizer seems to cause a large removal of calcium in the drainage waters, and it seems probable that the so-called acidity of soils fertilized with this substance is due, in part at least, to the solvent action of the ammonium sulfate on the calcium.

It has been shown in the feeding experiments carried on in this department that fish meal may be used as a source of a part of the protein in the ration for dairy cows, although, owing to the cost of such meal, it is doubtful if this would be the most profitable practice.

Extensive experiments with Molassine meal have shown that at usual relative prices it is not an economical food for cows.

The report of the chemist, found in later pages, discusses these matters in greater detail. In this report will be found also a fuller statement than that found earlier in this report of the work of the fertilizer, feed and dairy sections of the department, as well as a brief account of its general analytical and other work.

The botanical department has published a bulletin, "The Relation of Light to Greenhouse Culture." This presents the results of numerous experiments, which clearly show the close relation of varying light conditions to the development and health of crops. Upon these results are based important recommendations as to the location and construction of greenhouses.

The principal line of investigation followed in the department for several years — the effects of environment upon the growth of plants and crops, both in health and disease — has been continued.

A new form of spray nozzle, which is unusually efficient at a considerable distance from the point of discharge, has been perfected and patented.

Another subject which is receiving careful investigation is the relation of light to burning, following application of miscible oils.

The report of the botanist, found in later pages, discusses the matters here referred to in greater detail.

The investigation work in the poultry department has been well started. The principal line of work in progress is a thorough study of the capacity of each hen in a carefully selected breeding flock of 144 birds to produce: (*a*) eggs, (*b*) fertile eggs, (*c*) hatchable eggs, (*d*) viable chicks, (*e*) vigorous adults; and of the ability of each hen to transmit these qualities to her progeny.

In the department of pomology a bulletin, — "A Study of Variation in Apples," — found later in this report, has been issued. This bulletin presents the conclusions based on a study of climatic and other conditions upon the size, shape and other characteristics of apples. The investigation shows in general that a high temperature is favorable to the development of relatively flattened forms, and that, on the other hand, a low temperature, especially during a period immediately following the setting of the fruit, is favorable to elongated forms.

In the veterinary department methods of diagnosing infection with the bacterium which causes white diarrhœa in the chicks of the domestic fowl have been studied, and a bulletin on the subject — "On the Diagnosis of Infection with Bacterium Pullorum in the Domestic Fowl" — is found later in this report. The conclusion is that the examination of the eggs from suspected hens is not a practicable method for rapid diagnosis. On the other hand, macroscopic agglutination tests of the blood can be rapidly made and appear to give reliable indications.

In the entomological department the life history of the marguerite leaf miner (*Phytomyza chrysanthemi* Kow.) has been worked out and methods for its control discovered. Numerous insecticides have been tested. A very active and efficient parasite of the San José scale has been discovered. The work of this parasite has been found very effective, having resulted in the destruction of over 90 per cent. of the scales on the branches of trees examined in many cases. The entomologist has supplied parasitized scale to stations in a number of other States and is still supplying material on request. A fuller report concerning this scale and other work of the entomological department will be found in later pages.

The report of the treasurer immediately follows the director's report.

WM. P. BROOKS,

Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College, for the Year ending June 30, 1913.

United States Appropriations, 1912–13.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1913, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$15,000 00
Cr.		
By salaries,	$9,669 91	$12,583 58
labor,	2,319 19	931 46
publications,	386 23	–
postage and stationery,	108 45	21 16
freight and express,	6 25	14 31
heat, light, water and power,	20 76	110 94
chemicals and laboratory supplies,	99 68	514 26
seeds, plants and sundry supplies,	369 52	200 71
fertilizers,	726 47	88 05
feeding stuffs,	625 84	–
library,	118 08	22 03
tools, machinery and appliances,	204 77	5 29
furniture and fixtures,	36 25	9 00
scientific apparatus and specimens,	114 77	119 80
live stock,	6 40	–
traveling expenses,	131 13	76 61
contingent expenses,	–	–
buildings and land,	56 30	302 80
Total,	$15,000 00	$15,000 00

State Appropriation, 1912–13.

Cash balance brought forward from last fiscal year,	$6,787 28
Cash received from State Treasurer,	19,875 00
fertilizer fees,	10,444 99
farm products,	4,361 77
miscellaneous sources,	9,357 40
	$50,826 44

Cash paid for salaries,	$19,736 36
labor,	7,728 98
publications,	1,573 42
postage and stationery,	1,152 77
freight and express,	361 62
heat, light, water and power,	419 87
chemicals and laboratory supplies,	1,014 37
seeds, plants and sundry supplies,	1,104 18
fertilizers,	321 80
feeding stuffs,	893 68
library,	215 36
tools, machinery and appliances,	507 39
furniture and fixtures,	392 97
scientific apparatus and specimens,	104 40
live stock,	231 50
traveling expenses,	2,737 34
contingent expenses,	130 00
buildings and land,	625 88
balance,	11,574 55
	$50,826 44

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

1. Work of the Research Section.

Mr. Holland and assistant have devoted their time largely to a study of methods for a more thorough examination of butter fat in connection with our study of the effect of food upon the composition of milk. The work has been along the following lines: —

(*a*) The study of methods for the quantitative determination of the several insoluble fatty acids in butter fat. This has led to a very thorough study of the constitution of oils and fats, and resulted in a new process for the determination of hydroxy acids, both free and combined, of monoglycerides and diglycerides and of free insoluble alcohols. A paper on this subject will be published as a bulletin.

The study has led also to the development of a new process for the determination of stearic acid, which promises to be far preferable to that of Hehner and Mitchell on account of better thermostatic control during the filtration period.

The large amount of analytical work has, in itself, brought to light a mass of valuable information relative to solutions and details of manipulation which assure greater accuracy, and has resulted in a systematic correlation and standardization of the more common methods.

In addition to the above, butter fat from Jersey and Holstein cows at the beginning and end of lactation has been analyzed by recognized methods.

(*b*) The stability test with olive oil is being continued. While the physical changes are pronounced in many instances, the chemical are not sufficient as yet to merit a report.

(*c*) The work on insecticides has been comparatively light, and that largely advisory, with the exception of a careful examination of several samples of a new dry acid lead arsenate which the entomological department has tried the past season.

(*d*) Considerable time has been spent during the past year in the development of an adiabatic bomb calorimeter, in co-operation with Mr. E. A. Thompson, the able mechanic of Amherst. The apparatus is now completed and is proving quite satisfactory.

Mr. Morse and assistant have given their time to work on asparagus, cranberries, and to the action of sulfate of ammonia on the soil of field A of the station.

(*a*) The work of the past year on asparagus has been the completion of determinations of the composition of asparagus shoots and tops at successive stages of growth.

(*b*) The study of the composition of the drainage water of miniature cranberry bogs constructed on the station grounds has been continued on the same lines as last year, with still more attention to details of individual bogs.

(*c*) Effect of sulfate of ammonia on the soil. Particular attention has been given to composition of the drainage waters in field A and also to the ability of the soil in different plats of the field to absorb ammonia from the ammonium sulfate. One notes a large removal of calcium from the soils of the plats receiving ammonium sulfate. The so-called acidity of soils thus fertilized is probably due, in part at least, to the solvent action of the ammonium sulfate on the calcium.

Work in animal nutrition by Dr. Lindsey has included: —

(*a*) Digestion experiments with hay, corn meal, mangels, cabbage, cabbage leaves, Swedish turnips, Postum cereal residue, Mellin's Food waste, two kinds of fish meal and Molassine meal.

(*b*) A study of fish meal as a source of protein for dairy animals. A combination of bran, corn meal and cottonseed meal was compared with bran, corn meal and fish meal. The results indicated that it was perfectly feasible to use fish meal as a part of the ration for dairy animals; but at prices usually prevailing, it might make the ration a little more expensive.

(*c*) Molassine meal as an economic food for farm stock. The experiment indicated that, at the same moisture content, 1 ton of Molassine meal contained substantially 900 pounds of digestible organic matter, as against 1,400 pounds for corn meal. On this basis Molassine meal would have scarcely two-thirds of the nutritive value of the corn. An experiment with milch cows was made in which 4.3 pounds of corn meal were fed against 4.3 pounds of Molassine meal. The cows yielded some 14 per cent. more milk on the ration of which corn meal was a component.

(*d*) Studies have been continued on milk substitutes for dairy calves and the food cost of rearing dairy heifers until two years of age.

2. Work of the Fertilizer Section.

The principal work of the fertilizer section has been the annual inspection of commercial fertilizers. There has been a decided increase in the work of the fertilizer inspection from year to year. A larger number of commercial fertilizers has been registered, collected and analyzed during 1913 than for any previous year.

(*a*) *Fertilizers registered.*

One hundred manufacturers, importers and dealers, including the various branches of the large corporations, have secured certificates for the sale of fertilizer, agricultural chemicals, raw products and agricultural limes in the Massachusetts markets during the season of 1913. They may be classed, as follows: —

Complete fertilizers,	346
Fertilizers furnishing phosphoric acid and potash,	9
Ground bone, tankage and dry ground fish,	58
Chemicals and organic nitrogen compounds,	101
Agricultural limes,	27
	541

(*b*) *Fertilizers collected and analyzed.*

During the present season 133 towns were visited and 1,299 samples, representing 571 brands, were drawn from stock found in the possession of 381 different agents. This is 119 more samples, representing 44 more brands, than were taken during the previous year.

Seven hundred and forty-seven analyses (573 distinct brands) have been made during the year's inspection, as follows: —

Complete fertilizers,	427
Materials furnishing phosphoric acid and potash,	26
Ground bone, tankage and fish,	67
Nitrogen compounds,	95
Potash compounds,	45
Phosphoric acid compounds,	47
Lime compounds,	40
	747

The details regarding this inspection work will be found in Bulletin No. 147, published in December, 1913.

(*c*) *Other Work of the Fertilizer Section.*

Analyses were made of the ash of 4 samples of crimson clover plant and root, of 10 samples of asparagus plants and of 8 samples of tobacco leaves; 86 dry-matter determinations were also made on different field crops in connection with experimental work of this section.

In addition to the above, 326 different substances have been received from farmers, farmers' organizations and the various departments of the experiment station, and analyzed as follows: —

Fertilizers and by-products used as fertilizers,	149
Lime products,	19
Soils for lime requirement test.	68
Soils for complete analysis,	4
Dry-matter determinations,	86
	326

Considerable time has been given to co-operative work with the Association of Official Agricultural Chemists, Mr. L. S. Walker having served the association in the capacity of associate referee on phosphoric acid for the past season. In this work new methods for the analysis of basic slag phosphate have been studied, also new methods for the determination of available nitrogen and potash in fertilizers.

(*d*) *Field Experiments with Basic Slag Phosphate.*

This experiment was instituted at the request of the committee on basic slag, which was appointed by the Association of Official Agricultural Chemists for the purpose of determining, through vegetation tests, the efficiency of the phosphoric acid in basic slag phosphate.

In the fall of 1912, two acres of land, belonging to the Dillon farm, situated on the street leading from Amherst to Cushman, were leased for this experiment. It will be necessary, at first, to exhaust the soil of available phosphoric acid, which will require at least two years.

(*e*) *Field Experiments with New Mineral Fertilizer and Stone Meal.*

The field which served for this experiment was a part of the two-acre field leased from the Dillon farm and adjoining the land used for the basic slag experiment. The details of the experiment with each crop have been published in Fertilizer Bulletin No. 147.

(*f*) *Incompleted Work.*

A series of pot experiments was begun in the greenhouse during the fall and winter of 1912 to determine the efficiency of stone meal and the new mineral fertilizer as sources of plant food. At the present writing the dry-matter determinations have not been made on the crops grown, and the results will, therefore, be reserved for a future publication.

Many of the cotton mills in the eastern part of the State produce large quantities of a cotton waste product which shows, upon analysis, a considerable quantity of plant food in connection with a large amount of organic matter. An experiment was undertaken during the past season to show to what extent the product could be depended upon to take the place of manures and fertilizers. The results are not yet ready for publication.

3. REPORT OF THE FEED AND DAIRY SECTION.

(*a*) *The Feeding Stuffs Law (Acts and Resolves for 1912, Chapter 527).*

The first year's work with the revised feeding stuffs law was completed Sept. 1, 1913. There have been collected and examined, since the law went into effect, 1,115 samples, all of which practically conformed to their guarantees. The year has been considered one of adaptation to new conditions, and no prosecutions for violations of the law have been made, although where infringement of the statute was noted, attention was pointedly called to the matter through correspondence and conditions corrected. The text of the new law was published in Bulletin No. 142. Bulletin No. 146 gives the results of the inspection for 1913.

(*b*) *The Dairy Law (Acts and Resolves for 1912, Chapter 218).*

The dairy law, so called, requires that all milk inspectors and other operators who use the Babcock test as a means of determining the value of milk or cream shall secure a certificate of competency from the experiment station. It also provides that the glassware employed must be tested for accuracy by the experiment station and marked in such a way as to indicate the fact. In addition, an annual inspection of machines and apparatus in the various laboratories of the operators is required.

1. *Examination for Certificates.* — Twenty candidates were given certificates of proficiency during the year.

2. *Examination of Glassware.* — Six thousand three hundred and ninety-four pieces of Babcock glassware have been tested, of which only 34 pieces were condemned as inaccurate. The inspection shows an increasing number of 9-inch cream bottles

and of the 8 per cent. milk test bottles in use. They are more accurate than the 6-inch cream bottle and the 10 per cent. milk test bottle.

Following is a summary for the thirteen years the law has been in operation: —

YEAR.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
1912,	6,056	27	.45
1913,	6,394	34	.53
Totals,	46,602	1,958	4.20[1]

[1] Average.

3. *Inspection of Machinery and Apparatus.* — Mr. James T. Howard, as deputy inspector, has visited and inspected the Babcock machines and apparatus in 78 creameries, milk depots and milk inspectors' laboratories. Conditions were found much improved over those prevailing at the time of the previous inspection. In only one case was uninspected glassware found in use and but four machines were condemned. The use of the electrical tester is increasing rapidly. The larger number of the milk inspectors employ such a tester, as do also several of the milk depots. Most of the cities and larger towns are realizing the importance of safeguarding the milk supply and are giving their inspectors satisfactory equipment and well-furnished laboratories. Following is a list of creameries, milk depots and milk inspectors known to be using the Babcock test and visited by our inspector: —

1. *Creameries.*

Location.	Name.	Manager or Proprietor.
1. Amherst,	Amherst,	R. W. Pease, proprietor.
2. Amherst,	Fort River,[1]	E. A. King estate, proprietors.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
6. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
7. Egremont,	Egremont Co-operative,	E. A. Tyrell, manager.
8. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company,	W. Solomon, proprietor.
11. Monterey,	Berkshire Hills,	F. A. Campbell, manager.
12. Northfield,	Northfield Co-operative,	John E. Nye, manager.
13. Shelburne,	Shelburne Co-operative,	I. R. Barnard, manager.
14. Wyben Springs,	Wyben Springs Co-operative,	C. H. Kelso, manager.

[1] Testing done at Massachusetts Agricultural Experiment Station.

2. *Milk Depots.*

Location.	Name.	Manager.
1. Boston,	Boston Condensed Milk Company,	R. Burns.
2. Boston,	Boston Jersey Creamery,	E. F. Luce.
3. Boston,	Elm Farm Milk Company,	J. H. Knapp.
4. Boston,	H. P. Hood & Sons,	C. H. Hood.
5. Boston,	Oak Grove Farm,	John Alden.
6. Boston,	Plymouth Creamery Company,	R. Gardner.
7. Boston,	Turner Center Dairying Association,	I. L. Smith.
8. Boston,	Walker-Gordon Laboratory,	G. Franklin.
9. Boston,	D. Whiting & Sons,	George Whiting.
10. Cambridge,	C. Brigham Company,	J. K. Whiting.
11. Cheshire,	Ormsby Farms,	E. B. Penniman.
12. Everett,	Hampden Creamery,	F. H. Adams.
13. Pittsfield,	H. H. Prentice & Co.,	H. H. Prentice.
14. Sheffield,	Willow Brook Dairy,	Frank Percy.
15. Southborough,	Deerfoot Farm,	C. H. Newton.
16. Springfield,	Tait Brothers,	H. Tait.
17. Worcester,	C. Brigham Company,	N. W. King.
18. West Stockbridge,	Borden Milk Company,	T. L. Roberts.

3. *Milk Inspectors.*

Location.	Inspector.	Location.	Inspector.
1. Adams,	A. G. Potter.	24. Newton,	Arthur Hudson.
2. Andover,	F. H. Stacey.	25. New Bedford,	H. B. Hamilton.
3. Arlington,	L. L. Pierce.	26. North Adams,	H. Tower.
4. Barnstable,	G. T. Mecarta.	27. Northampton,	G. R. Turner.
5. Boston,	J. O. Jordan.	28. Pittsfield,	E. L. Hannum.
6. Brockton,	G. G. Bolling.	29. Plainville,	John Eiden.
7. Cambridge,	W. A. Noonan.	30. Revere,	J. E. Lamb.
8. Chelsea,	W. S. Walkley.	31. South Hadley,	G. F. Boudreau.
9. Chicopee,	C. L. O'Brien.	32. Somerville,	H. E. Bowman.
10. Clinton,	G. L. Chase.	33. Springfield,	S. C. Downs.
11. Everett,	E. Clarence Colby.	34. Springfield,	Emerson Laboratory.[1]
12. Fall River,	H. Boisseau.	35. Taunton,	L. I. Tucker.
13. Fitchburg,	J. F. Bresnahan.	36. Wakefield,	H. A. Symonds.
14. Gardner,	C. W. Shippee.	37. Waltham,	A. L. Stone.
15. Greenfield,	G. P. Moore.	38. Ware,	F. E. Marsh.
16. Haverhill,	H. L. Conner.	39. Watertown,	L. C. Simmons.
17. Holyoke,	D. P. Hartnett.	40. Wellesley,	R. W. Hoyt.
18. Lawrence,	J. H. Tobin.	41. Westfield,	W. M. Porter.
19. Lowell,	M. Marster.	42. West Springfield,	N. T. Smith.
20. Lynn,	H. P. Bennett.	43. Winchendon,	G. W. Stanbridge.
21. Millbury,	F. A. Watkins.	44. Winchester,	Morris Dinneen.
22. Malden,	J. I. Sanford.	45. Woburn,	E. P. Kelley.
23. Medford,	Winslow Joyce.	46. Worcester,	G. L. Berg.

[1] Does work for the State Dairy Bureau.

(*c*) *Water Analysis.*

Ninety-three samples of water have been examined during the past year at the usual charge of $3 a sample. A large number of these, especially those samples taken from wells, have been condemned as unfit for domestic use. Public water supplies are supervised by the State Board of Health.

(*d*) *Milk, Cream and Feeds for Free Examination.*

Many samples of milk, cream and feeding stuffs are received each year at the laboratory for free examination. In general, it is preferred that application be made for sampling and shipping instructions before the sample is submitted. Only samples of direct agricultural interest are considered, and the experiment station will not act in the capacity of a private chemist for a feed manufacturer, milk depot or creamery.

(*e*) *Miscellaneous Work.*

In addition to the work already described, this section has co-operated with other departments of the college and State, as follows: —

1. It has arranged exhibits and furnished speakers in co-operation with the extension service for fairs, farmers' meetings and expositions.

2. It has co-operated with the Bowker Fertilizer Company in making starch determinations on potatoes in connection with the awarding of prizes.

3. It has co-operated with the agricultural department of the college in making analyses of milk in connection with the awarding of prizes at a dairy show held during "farmers' week."

4. It has co-operated with the agricultural department of the experiment station in making analyses of the corn plant to determine the effect of frosts upon the nutritive value of the plant.

5. It has assisted the horticultural department of the college by analyzing root crops to determine the effect of cold storage in modifying their chemical character.

(*f*) *Testing of Pure-bred Cows for Advanced Registry.*

During the year, ten different men have been used for the Holstein-Friesian work, and the entire time of three other men has been taken in conducting the work for the Guernsey, Jersey, Ayrshire and Brown Swiss associations. From Dec. 1, 1912, to Dec. 1, 1913, 86 Guernsey, 122 Jersey, 2 Brown Swiss, 18 Ayrshire and 4 Holstein yearly tests have been completed. There are now on test 110 Jerseys, 111 Guernseys, 24 Ayrshires and 1 Brown Swiss, located at 28 different farms. For the Holstein-Friesian Association there have been completed 120 seven-day tests, 10 thirty-day tests, 5 fourteen-day tests and 1 sixty-day test.

4. Numerical Summary of Substances examined in the Chemical Laboratory.

The following substances have been received and examined: 93 samples of water, 305 milk, 1,452 cream, 3 ice cream, 2 butter, 191 feedstuffs, 149 fertilizers and fertilizer refuse materials, 72 soils, 19 lime products, 22 plant ash and 6 miscellaneous. There have also been examined in connection with experiments in progress by the several departments of the station, 167 samples of milk and cream, 193 cattle feeds and 352 agricultural plants. In connection with the control work, there have been collected 1,299 samples of fertilizer and 1,115 samples of feedstuffs. In addition, 30 samples of coal have been analyzed by the research section for the college heating plant. The total for the year was 5,470. This does not include the work of the research section, where many analyses are made in connection with research problems, nor the work under the dairy law already reported.

5. Correspondence.

The number of letters sent out during the year is about 5,000. The larger part of the correspondence is devoted to work in connection with our several inspection laws. A considerable amount of time, however, is devoted to the answering of special inquiries from the farmers of this State.

REPORT OF THE BOTANIST.

GEO. E. STONE.

During the past year the work in this department has been along the usual lines, attention being given to new problems as they arise. The drought was so severe that an unprecedented number of urgent calls for investigation of diseases had to be attended to, and the diagnosis work taxed our resources severely.

The usual seed work, consisting of separation and tests for germination and purity, has been carried on, but the equipment is deficient, especially for germination work.

Mr. G. H. Chapman, research assistant, has been studying at the University of Prague on leave of absence, and his place has been taken by Mr. O. L. Clark, who has spent three years in German universities and was at one time assistant to Prof. L. Jost of Strassburg University, Elsass.

Many of the lines of investigation which were outlined in our last annual report have been continued, some of them being practically completed and ready for publication. Studies of the diseases of crops and of trees, together with investigations of new methods in tree surgery and of long-distance, high-pressure spraying nozzles especially adapted to shade tree work, have been continued. Some of the nozzles have already proved very satisfactory, and have been reported as cutting the expense of spraying one-half, without any decrease in efficiency. One has been patented in the writer's name and assigned to the college, with the provision that any income derived from its sale shall be used by this department subject to the approval of the committee on experiment department and of the director of the station.

Study has been made of a new bacterial disease of the tomato, and experiments made with extermination of weeds in lawns, etc., and tests of various proprietary sprays and fungicides and of crude by-products recommended as soil fungicides and sprays, some of which have proved very efficient in controlling the potato scab. (See twenty-fifth annual report.)

Experiments relating to the exclusion of roots from drain tile have been continued, and positive results obtained. Experiments with chemical methods to destroy horsetail (*Equisetum*), one of the worst weeds in cranberry bogs, also give promise of being successful. Attention has been given to the influence of soil moisture on seed germination, and some problems relating to the stimulating effects on crops of various gases have been taken up. Further study is being made of soil sterilization, particularly of new methods; and also of malnutrition of plants.

A number of problems properly coming under the Adams fund project, and covering in a broad way the effects of meteorological conditions on plants, are being studied as follows: the relation of light to burning from spraying with fungicides and insecticides; relation of light to burning from miscible oils; nature and cause of burning by fumigation with various gases; effects of electricity on nitrogen fixation in soils and on the stimulation of plants in general.

Some of these investigations have been published during the past year in Bulletin No. 144, "The Relation of Light to Greenhouse Culture," a physiological and pathological study of the subject; another paper dealing with the relation of light to burning from miscible oils is in preparation; and still others on research problems which have been studied for some time in our laboratory.

REPORT OF THE ENTOMOLOGIST.

H. T. FERNALD. √

The entomological work of the experiment station during 1913 has been mainly along lines indicated in previous reports. It has not seemed wise to take up many new subjects for investigation, but, instead, to devote most of the time available to those already under way.

Experiments for the control of the onion maggot, begun in 1912, were discussed in the last annual report. The work of the first season indicated that the methods recommended by most writers were either ineffective or too costly for practical use. The season of 1913 was therefore devoted to the testing of new materials as insecticides, particularly applied during the planting process, in order to avoid the expense of special applications. None of the materials thus tested proved to be entirely satisfactory, though one or two were sufficiently so to warrant repetition the coming year, when further experiments will accordingly be made.

Studies on the marguerite leaf miner (*Phytomyza chrysanthemi* Kow.) have been made at intervals at this station for a number of years, as opportunity offered. The work has at last been completed, the entire life history of this greenhouse pest having been worked out, together with methods for its control, and the completed paper by Mr. M. T. Smulyan is about ready for publication.

Observations of the dates of hatching of the more important scale insects of this region have been continued, and the data which have been accumulating on this subject should prove of much value, at least locally. The work should be continued at least two or three years longer.

The box leaf miner (*Monarthropalpus buxi* Lab.), a recent arrival in this country, has caused much injury to box trees and hedges. Its life history and habits are little understood, and a study of this subject and of control methods has been begun.

Tests of various insecticides have been made from time to time, though in most cases sufficient opportunity was not available for anything like sufficient experiments to permit final conclusions. Of the materials tested, the dry arsenate of lead manufactured by the Corona Chemical Company proved very satisfactory, as did also Bowker's lime sulfur prepared by the Bowker Chemical Company, and lead arsenate paste furnished by the Powers, Weightman, Rosengarten Company. Kylscale and soluble sulfur did not give as satisfactory results in controlling the San José scale as had been hoped, though many of the insects were undoubtedly destroyed.

Under the Adams fund, work has been continued on the projects already authorized. In the study of the importance of wasps as parasites it had already been found that any determination of this for the different kinds must necessitate a recognition of the different species, of their distribution and relative abundance. To clear up these points, a study of the material from this country in Europe was necessary, and fortunately this became possible last year. The way is now clear to continue this work on a sound basis as a result of these studies, and it is being prosecuted as rapidly as possible.

The tests of various insecticides, referred to in previous reports, have been continued, and about 4,000 are now recorded. The results thus far have been as satisfactory as could be expected, and the project will be continued.

The work of the apiarist of the station is stated as follows: —

As reported in person to Dr. Evans, Sept. 29, 1913, the Adams fund project of the apiarist of the station has progressed along its originally intended lines. Effort was made to ascertain the number of visits per unit of time which are made by a bee to flowers, as, for instance, to the clover. The visits are a complex of reactions, which thus far are interpreted with consideration of weather, abundance of nectar in the flowers, the frequency of visits of other bees to the same flower, the time of day, and nectar-yielding conditions. Earlier experiments with bees in reaction to tissue paper flowers evinced that either touch or odor was a factor as well as color. Here again odor apparently was involved in the case of clover. Apart from the jurisdiction of the college, it was reported that significant findings had been made concerning dissemination, persistency, and especially the incipient stages of the brood diseases of bees, respectively European foul brood, American foul brood and sac brood. Observations were also made concerning the curative value of the so-called "dequeening process," and the importance of Italianization. Equipment has been procured for an experiment the current month concerning stimuli which attract bees.

The discovery of an active and very efficient parasite of the San José scale was made at this station during the year, and deserves somewhat more than casual mention.

Numerous specimens of this scale are examined each year. Generally only a few parasites have been noted, these being the well-known *Aphelinus fuscipennis* How., and not sufficiently abundant to be of any importance. In the fall of 1912, however, a large amount of parasitism was observed, and the parasites were accordingly bred. They proved to be an unknown species which is described and published in the Annals of the Entomological Society of America for March, 1913, by Mr. D. G. Tower, a graduate student at the college, in whose hands this subject had been placed to follow up. During the year Mr. Tower has continued his observations on this insect and has its life history nearly completed.

During 1913 this parasite has been extremely abundant, and in many cases has parasitized over 90 per cent. of the scales on the branches of the plants examined. It has also been found in other parts of the State, and has been reported from Connecticut, New York and Pennsylvania, and is probably still more widely distributed. The station has sent out supplies of parasitized scales to a number of other States and is still supplying material on request.

That this insect may be of great value is evident by its work. It is only fair, however, to call attention to the fact that such insects often appear in great abundance for a time, after which they become less numerous and accordingly far less important. In any case, so long as a single San José scale can give rise to over three billions of descendants in a single year (Bulletin 4, Division of Entomology, United States Department of Agriculture) it can hardly be anticipated that spraying for this insect can be omitted.

The correspondence during the year has been fully as large as heretofore, and many insects sent in have been species of which little is known. This has necessitated a large amount of research, and often the rearing of the insects before satisfactory information as to methods of control could be furnished.

Insects found by the nursery inspectors of the State on imported nursery stock are sent to this station for identification, and this phase of the work, being quite novel, has also taken considerable time. A number of foreign pests not at present established in this country have been discovered in this way.

The collections have constantly increased in size and value. There are now probably considerably over 100,000 pinned specimens, besides many samples of work done by insects, a large number of mounted slides and many alcoholic specimens. The proper care of a collection of this size, and of adding to it material collected each year, is sufficient to occupy the entire time of one man. At present it is partially attended to as opportunity offers. The time is rapidly approaching when it must receive more attention or greatly lose in value.

REPORT OF THE POULTRY HUSBANDMAN.

JOHN C. GRAHAM.

The chief investigations started last year, and which are still in progress, consist of a thorough study of the capacity of each hen to produce (*a*) eggs, (*b*) fertile eggs, (*c*) hatchable eggs, (*d*) viable chicks, (*e*) vigorous adults, and of the ability of each bird to transmit these qualities to its progeny.

Secondary studies are being made of the inheritance of various color and form characteristics. To this end, 144 pullets were trapnested through the year 1913.

During the breeding season eggs were incubated, a record being kept of each egg and its fate, and over 2,000 chicks were hatched, as many as possible being reared to maturity.

Feather charts of all adults have been made. Besides the main experiments, various trials have been made, from time to time, of such problems as suggest themselves with a view of testing their possibilities. Considerable time has been spent on autopsies of birds sent in by poultrymen.

During the last half of the hatching season it was found that coccidiotis had gained such headway that a large number of chicks were lost from this disease, besides injuring many more. There are so many obscure points in the life history of the causative organism that a large amount of time has to be devoted to its study, to the disadvantage of our other investigations; however, certain points regarding the disease had to be made out before we could proceed with our other work with confidence. These points have now been studied with sufficient care to outline a favorable method of management.

VETERINARY DEPARTMENT.

ON THE DIAGNOSIS OF INFECTION WITH BACTERIUM PULLORUM IN THE DOMESTIC FOWL.

By GEO. EDWARD GAGE

WITH THE ASSISTANCE OF

BERYL H. PAIGE AND HAROLD W. HYLAND

(From the Department of Veterinary Science)

Massachusetts Agricultural Experiment Station.

During the last two years the scientific evidence at hand concerning the rôle of *Bacterium pullorum* (Rettger) in bacillary white diarrhœa of young chicks and relations of it to ovarian infection in adult fowls has been most conclusive. Rettger and Stoneburn[1] pointed out the fact that adult hens were the original source of infection to young chicks suffering with bacillary white diarrhœa.

In their report of 1911[2] they further substantiate the results of the previous paper in that adult hens are the original source of infection; that eggs from infected hens may contain the organism in the yolk.

In a third report, 1912,[3] they fully support statements of their previous work concerning ovarian infection, and they conclude that the ovaries may become infected by contact of the hens with infected hens or by artificial infection of the litter. "The infection is, in all probability, acquired through the mouth."

Gage, in 1910–11,[4] in publication of reports from experiments conducted at the Maryland Experiment Station, concluded that Rettger and Stoneburn were correct in their work of the previous year, corroborating the fact that white diarrhœa, as poultrymen understand it, is a bacillary disease caused by *Bacterium pullorum* (R), and that the hen is the original source of infection, transmitting the organism from the ovary to the eggs.

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[1] Rettger, L. F., and Stoneburn, F. H.: Bulletin No. 60, 1909, Storrs Agricultural Experiment Station. "Bacillary white diarrhœa of young chicks."

[2] Rettger, L. F., and Stoneburn, F. H., Bulletin No. 68, 1911, Storrs Agricultural Experiment Station. "Bacillary white diarrhœa of young chicks" (second report).

[3] Rettger, L. F., Stoneburn, F. H., and Kirkpatrick, Wm. F.: Bulletin No. 74, 1912. "Bacillary white diarrhœa of young chicks" (third report).

[4] Gage, Geo. Edward: "Notes on ovarian infection with *Bacterium pullorum* (Rettger) in the domestic fowl." Journal Medical Research, Vol. XXIV., No. ; N. S., Vol. XIX., No. 3; June, 1911, pp. 491–496.

Jones, in his reports of 1910[1] and 1911,[2] again supports the work of Rettger and Stoneburn, and also finds that the local disease in the ovary of adult fowls may be produced by the intravenous injections of *Bacterium pullorum.*

From these reports it can be seen that the problem now consists in methods of determining the presence of the virus in adult hens. From examination of eggs it has been almost impossible to make a diagnosis of this infection within a short time, since *Bacterium pullorum* is eliminated so irregularly that it is necessary, often, to examine all eggs laid by a suspected hen over a long period.

Jones[3] suggested the use of an agglutination similar to that used in the diagnosis of glanders and contagious abortion for detecting ovarian infection, and in a later paper[4] has given an excellent example of the value of the macroscopic agglutination test for detecting individuals harboring *B. pullorum.*

It is the object of this paper to present the results of the work conducted in the investigational laboratory of the department of veterinary science concerning the diagnosis of this ovarian infection in adult hens by egg analysis and by macroscopic agglutination tests, together with data which have been obtained concerning the various factors which must be considered in making the tests. It shall also serve to demonstrate the practicability of these tests as a routine laboratory procedure, the work having been performed in many respects by three different technicians.

The subjects used for these experiments were all suspected of harboring the virus of *Bacterium pullorum.* The organism had been detected in the yolk of eggs from hens Nos. 267, 792, 452, 714 and 464 prior to their arrival at the laboratory. Hens Nos. 1, 2, 4, 5, 6, 7, 8, 10, 13, 18, 22, 34, 35, 46, 48, 49, 52, 53, 60, 61, 77, 312, 315, 618 and 2096 were all suspects. Hens Nos. 1, 2, 4, 5, 6, 7, 8, 10, 13, 18, 22, 48, 52 and 53 had been inoculated intravenously with 1 c.c. of a bouillon suspension of a culture of *Bacterium pullorum*[5] known according to the filing-denotation of *Bacterium pullorum* in this laboratory as M., which had been isolated from the ovaries of a white Orpington pullet, and proven absolutely to be capable of producing the disease in young chicks. Hens Nos. 34, 35, 46, 49, 60, 61, 77, 312, 315, 618 and 2096 had been closely associated with hens which had received the intravenous injection, but, so far as the author has been able to ascertain, only for a short time. Since the data on these last birds were so incomplete concerning their histories, it was considered wise to put all together and include them all in the tests. Birds Nos. 1, 2, 4, 5, 6, 7, 8, 10, 13, 18, 22, 48, 52 and 53 were all more than three years old, and were sent to this laboratory through the kindness of Director H. J. Patterson of the Maryland Agricultural Experiment Station, where the author had started work to determine the possibility of artificial infection of ovarian tissue by intravenous injections of the organisms, — work which was interrupted before final results could be obtained.[1] Jones,[2] however, was successful in his attempts to bring about ovarian infection with *Bact. pullorum* by the injection of pure cultures of the organism into the blood circulation of hens.

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[1] Jones, F. S.: "Fatal septecemia or bacillary white diarrhœa in young chickens." Annual Report of the New York State Veterinary College for 1910, pp. 111–129.

[2] Jones, F. S.: "Further studies on bacillary white diarrhœa in young chickens." Report, New York State Veterinary College, 1910–11, pp. 69–88.

[3] Jones, F. S.: Report, New York State Veterinary College for 1910–11, p. 76.

[4] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum.*" Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485–495.

[5] Gage: "Notes on ovarian infection with *Bacterium pullorum* in the domestic fowl." Journal Medical Research, Vol. XXIV., No. 5; N. S., Vol. XIX., No. 3, p. 493.

All individuals retained for these tests were trap-nested and complete egg records kept of each hen.

METHODS EMPLOYED IN THE EXAMINATION OF EGGS FOR BACTERIUM PULLORUM.

The object primarily in making the examination of all eggs laid by these suspected hens was to determine if possible the presence of the organism in the yolk, which would be of value in checking up the work in connection with any of the serum reactions which later might prove positive. The method used for these egg analyses was essentially that used by Rettger.[3] Eggs were allowed to remain several minutes in carbolic acid (1–40) and dried with sterile absorbent cotton. The end of the egg was sterilized by flaming, the flamed portion cut around with sterile scissors. The albumin was carefully separated from the yolk and the yolk inserted into a large test tube (Buchner type) containing about 30 c.c. sterile bouillon. In the first part of the egg-testing work fresh eggs were studied, but later the eggs were incubated prior to the testing, and in some instances sufficiently long for embryos to develop. In such cases a sterile platinum loop or scissors were used to aid in freeing the embryo from the shell and albumin. If embryo was very large it was inserted into sterile bouillon along with the rest of the yolk. The disintegrated egg yolks in bouillon were placed in the incubator at 38° C. and allowed to remain there for varying lengths of time, the shortest period being twenty-four hours and the longest two hundred and eighty hours. After tubes were taken from bacteriological incubator the material was thoroughly mixed and four samples streaked on four different tubes of agar. These were placed in the bacteriological incubator and examined macroscopically for the presence of the typical *Bact. pullorum* colonies at the end of twenty-four, forty-eight and seventy-two hours. A tube was not considered negative until it had been allowed to incubate for seventy-two hours. In many cases when there was doubt concerning organism, all materials were plated out and colony again streaked from such plates.

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[1] Work referred to by Dr. Rettger in Bulletin No. 74, Storrs Agricultural Experiment Station Storrs, Conn., p. 162, line 12.

[2] Jones, F. S., "Further studies on bacillary white diarrhœa in young chickens." Report, New York State Veterinary College, 1910–11, pp. 69–88.

[3] Rettger, L. F., and Stoneburn, F. H., Bulletin No. 68, 1911, Storrs Agricultural Experiment Station, "Bacillary white diarrhœa of young chicks" (second report).

In view of the fact that many inquiries had been received here at this laboratory concerning the egg test for the determination of this organism, it was decided worth while to test all eggs laid by these suspected hens, and also to record what effect the retention of egg prior to testing, and length of time egg material remained in the bacteriological incubator at 38° to 39° C., had in facilitating isolation of the organism.

In tables 1, 2 and 3 are exhibited the data obtained from the egg tests tabulated to show when egg was laid, by which hen laid, and whether the organism was isolated from the hen, a fact designated by a plus sign. It also shows to how long a period of incubation the egg material in bouillon was submitted before being streaked on the agar slants.

During the period of making the first egg tests all eggs were retained at room temperature until tested, or they were tested on the same day, soon after laying. Later, however, it was found advisable to retain at the temperature of the bacteriological incubator, about 39° C., before inserting in sterile bouillon, to afford perhaps a preliminary proliferation of the organism.

TABLE 1.

Egg Record of Hens 267-61 showing date of egg laid and egg in which Bacterium pullorum was detected. July

HEN NO → DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
267								× −		× −	× −	× −		× −	× −	× −		× −										× −	× −	× −	× −
8								× −		× −	× −		× −	× −		× −		× −			× −		× −		× −			× −		× −	× −
315								× −		× −	× −			× −		× −	× −									× −	× −		× −	× −	
1								× −				× −		× −	× −		× −														× −
49									× −	× −		× −	× −		× −	× −		× −	× −								× −	× −		× −	× −
60									× −		× −	× −		× −	× −	× −		× −	× −		× −				× −	× −		× −	× −	× −	
22									× −			× −								× −											
10										× −	× −		× −	× −		× −	× −				× −					× −	× −		× −	× +	
18										× −		× −	× −		× −		× −		× −		× −			× −		× +		× −		× −	× −
77										× −	× −		× −	× −	× −	× −	× −		× −	× −		× −		× −		× −	× −	× −		× −	× −
6										× −		× −	× −		× −	× +	× +		× +												
206										× −			× −		× −	× −	× −	× −	× −		× −		× −		× −	× −	× −	× −		× −	× −
5										× −	× −		× −	× −		× −	× −		× −				× −		× −		× −		× −	× +	
2										× −		× −	× −		× −	× −		× −								× +	× −		× −	× +	
4										× −	× −		× −		× −	× −		× −	× −		× −				× −						
35										× −		× −	× −		× −	× −		× −	× −		× −	× −	× −		× −	× −	× −		× −		
48										× −		× −	× −		× −		× −		× −											× −	× −
68										× −		× −	× −		× −	× −		× −			× −				× −	× −		× −	× −		× −
7											× −			× −		× −	× −		× −								× −		× −	× −	
312											× −		× −																		
46											× −		× −		× −	× −		× −		× −						× −	× −		× −		× −
52											× −		× −	× −	× −		× −	× −		× −	× +		× +	× −	× −				× −		
13											× −	×		× −	× −		× −		× −	× −		× +				× +		× −	× −		× −
53													× −					× −	× −		× −		× −		× −		× −		× −		× −
452												× −	× −		× −	× −															
792															× −	× −		× −		× −			× +		× +		× −			× +	
714															×		×			×							× +		×	×	
34														× −										× −	× −		× −	× −		× −	
464														× −			× −	×	× −		× −					× −		× −		× −	
61																									× −		× −	× −			× −

X = egg laid
− = B. pullorum not detected
+ = B. pullorum detected.

TABLE 2.

Egg Record of Hens 267–61 showing date of egg laid and egg in which Bacterium pullorum was detected. August

Hen No. / Date →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
267	X–	X–		X–	X–		X–						X–		X–	X–	X–		X–		X–	X–	X–	X–			X–				
8		X–		X–		X–		X–				X–		X–		X–		X+							X–			X–		X–	
315	X–	X–		X–	X–		X–	X–				X–		X–		X–	X–		X–	X–		X–		X–		X–		X–		X–	X–
1	X–		X–	X–				X–		X–		X–			X+																
49	X–		X–	X–		X–	X–		X–	X–		X–	X–		X–	X–	X–		X–	X–		X–		X–	X–		X–				X
60	X–		X–													X–	X–		X–	X–		X–									
22													X–	X–		X–	X–		X–	X–		X–				X–					
10	X–	X–		X–		X–				X–		X+		X–	X+		X–														
18						X–					X–		X–				X–				X–		X–		X–						
77	X–	X–		X–	X–	X–	X–	X–	X–		X–	X–	X–	X–		X–	X–	X–	X–		X–		X–	X–			X–			X–	
6			X–								DIED																				
296		X–	X–		X–		X–					X+	X–	X–		X–	X–	X–	X–		X–	X–	X–		X–						
5	X–	X+		X+	X–		X–	X–	DIED																						
2	X–	X–																													
4							X–		X–		X–	X–		X–	X–		X–			X–				X–				X–			X–
35	X–				X–	X–				X–	X–	X–		X–	X–		X–				X–				X–						X–
48		X–	X–		X–			X–			X–								X–		X–		X–		X–						
618	X–	X–		X–	X–			X–	X–		X–	X–		X–	X–	X–		X–	X–	X–		X–		X–							
7	X–		X–	X+		X–		X–			X–		X+		X–		X–		X–		X–										
46	X–			X–		X–	X–	X–		X–	X–	X–		X–	X–																
13		X–	X–		X–	X–		X–	X–				X–		X–	X–		X–		X–					X+						
53	X	–			X–	X–			X–	X–			X–		X–	X–		X–		X–											
792	X–	X–			X–	–			X–		X–	X+		X–	X–			X–		X–	X–		X–	X–		X–		X–		X–	
714	X–	X–		X–		X–	X–		X–		X–		X+		X–		X–									X–		X–		X–	
34	X–		X–		X–								X–	X–		X–	X–	X–		X–		X–		X–							
364						X–					X–																				
61	X–	X–		X–	X–				X–		X–	X–		X–	X–	X–		X–										X–		X–	X–

X = egg laid
– = B. pullorum not detected
+ = B. pullorum detected

TABLE 3.

Egg Record of Hens 267-61 showing date of egg laid and egg in which Bacterium pullorum was detected September

HEN NO Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
267																			X –	X –	X –				X –		X –				
8																															
315		X –		X –		X –				X –		X –		X –			X –			X –	X –										
1																															
49		X –		X –	X –																–										
60	X –		X –	X –																		X –			X –						
22																															
10																															
18																															
77																															
6																															
2096									X –	X –		X –						X –		X –											
5																															
2																															
4				X –	X –				X –	X –		X –				X –					X –		X –								
35		X –																													
48				X –		X +																									
618																															
7																															
312																															
46																															
52																															
13																															
53																										X –						
452																															
792	X –																														
714	X –																				X +										
34								X –																							
464											X –		X +			X +															
61																		X –													

X = egg laid
– = B. pullorum not detected
+ = B. pullorum detected

From Table 4, it can be seen that of the 619 eggs tested *Bacterium pullorum* was detected in eggs laid by hen No. 10, once during July, egg laid 7–30–13; by hen No. 18, once during July, egg laid 7–26–13; by hen No. 6, three times during the month, eggs laid 7–16–13, 7–17–13 and 7–19–13; by hen No. 5, once during month, egg laid 7–30–13; by hen No. 2, twice during month, eggs laid 7–26–13 and 7–30–13; by hen No. 52, twice during month, eggs laid 7–21–13 and 7–23–13; by hen No. 13, twice, eggs laid 7–22–13 and 7–26–13; by hen No. 792, three times, eggs laid 7–23–13, 7–25–13 and 7–30–13; by hen No. 714, once during month, egg laid 7–27–13. During August from hen No. 8 *Bact. pullorum* was isolated from one egg laid 8–18–13; by hen No. 1, once during month, egg laid 8–15–13; by hen No. 10, twice, eggs laid 8–12–13 and 8–15–13; by hen No. 2096, once during month, egg laid 8–12–13; by hen No. 5, twice, eggs laid 8–2–13 and 8–4–13; by hen No. 7, twice, eggs laid 8–4–13 and 8–13–13; by hen No. 13, once, egg laid 8–25–13; by hen No. 792, once, egg laid 8–12–13; by hen No. 714, once, egg laid 8–13–13. During September the organism was isolated from egg of hen No. 48, once, egg laid 9–6–13; by hen No. 714, once, egg laid 9–21–13; by hen No. 464, twice, eggs laid 9–13–13 and 9–16–13.

Of the 16 cultures of *Bacterium pullorum* isolated from eggs in July the yolk material of 13 in sterile bouillon had been retained in bacteriological incubator for more than seventy-two hours. Of the 12 isolated in August, all yolk material in bouillon had been retained in bacteriological incubator more than seventy-two hours. From the 4 isolated in September, the egg material had been in incubator but forty-eight hours. After August 1 it was planned to put all eggs in bacteriological incubator prior to testing, and this brought forth egg material which yielded cultures of *Bacterium pullorum* which had not been detected in July, namely, the infection was detected in hen No. 8, hen No. 1, hen No. 2096 and hen No. 7. By the previous incubation of eggs, for one to three days, the organism had multiplied to such an extent that it was possible to detect the organisms in 7 individuals in whom it had not been detected in July. From egg material incubated in bacteriological incubator at 38° to 39° C. for seventy-two hours or longer it was much easier to detect the organism. Usually it was present in large numbers, and the organism on the agar-slant usually became visible within the first twenty-four hours' incubation. In general it may be stated that egg testing of these hens' eggs yielded better results after this preliminary incubation of the eggs in bacteriological incubator, and it was found always advisable to wait seventy-two hours before considering a sample negative as regards colonies on subsequent agar streaks.

From what has been determined here, and from the work of Rettger and Jones, it can be clearly seen that diagnosis by egg testing is impractical. In some cases, however, the egg testing has given results with the examination of the first few eggs. According to the work in this laboratory, it has been found that if a bird is badly infected persistence in egg testing will usually yield a positive result. Of the 619 eggs tested from hens in

TABLE 4.

TABLE SHOWING WHEN EGG WAS LAID, HEN NUMBER, NUMBER OF HOURS MATERIAL WAS RETAINED IN BACTERIOLOGICAL INCUBATOR

+ = ORGANISM FOUND
− = ORGANISM NOT FOUND

JULY	24 HRS	43 HRS	48 HRS	65 HRS	72 HRS	88 HRS	90 HRS	97 HRS	110 HRS	120 HRS	136 HRS	140 HRS	163 HRS	168 HRS	190 HRS	210 HRS	256 HRS	263 HRS	283 HRS
	6 7/16 ⊕	22 7/20 -	267 7/8 -	267 7/12 -	267 7/10 -	267 7/8 -	267 7/16 -	8 7/28 -	315 7/26 -	8 7/21 -	267 7/28 -	1 8/3 -	60 7/19 -	267 7/28 -	8 7/25 -	267 7/31 -	61 7/28 -	49 8/22 -	618 7/28 -
			267 7/11 -	8 7/13 -	8 7/8 -	8 7/8 -	267 7/29 -	49 7/27 -	315 7/27 -	8 7/23 -	315 7/30 -	49 8/3 -	35 7/29 -		60 7/25 -	8 7/31 -			13 7/28 -
	35 7/12 -		267 7/14 -	8 7/14 -	8 7/10 -	315 7/7 -	315 7/16 -	49 7/28 -	60 7/26 -	60 7/21 -	49 7/30 -	60 8/3 -	48 7/30 -		10 7/26 -	1 7/31 -			
			267 7/15 -	1 7/8 -	315 7/10 -	1 7/7 -	315 7/29 -	10 7/27 -	77 7/26 -	10 7/21 -	60 7/28 -	35 8/3 -	46 7/31 -		18 7/26 ⊕	49 7/31 -			
			8 7/11 -	1 7/12 -	315 7/11 -	49 7/8 -	18 7/15 -	18 7/28 -	77 7/27 -	18 7/21 -	60 7/29 -	7 8/3 -	53 7/19 -		2096 7/25 -	10 7/30 ⊕			
			8 7/16 -	60 7/12 -	49 7/9 -	60 7/8 -	5 7/16 -	2 7/29 -	77 7/28 -	77 7/20 -	60 7/30 -	61 8/4 -	53 7/29 -		5 7/25 -	18 7/31 -			
			8 7/30 -	22 7/12 -	49 7/19 -	10 7/7 -	35 7/16 -	618 7/29 -	2096 7/26 -	77 7/12 -	10 7/29 -		AUGUST		4 7/25 -	77 7/31 -			
			315 7/8 -	18 7/12 -	60 7/9 -	18 7/7 -	618 7/16 -	46 7/27 -	2096 7/27 -	77 7/24 -	18 7/30 -		267 8/1 -		35 7/25 -	2096 7/31 -			
			315 7/14 -	77 7/13 -	22 7/9 -	77 7/7 -	7 7/16 -	34 7/27 -	5 7/27 -	2096 7/21 -	2096 7/28 -		8 8/2 -		618 7/25 -	5 7/29 -			
			1 7/14 -	77 7/15 -	10 7/10 -	77 7/19 -	46 7/16 -	464 7/28 -	2 7/26 ⊕	2096 7/23 -	2096 7/30 -		315 8/24 -		52 7/25 -	48 7/31 -			
			1 7/15 -	6 7/12 -	10 7/11 -	6 7/17 ⊕	13 7/15 -	AUGUST	2 7/26 -	5 7/23 -	5 7/30 ⊕		315 8/26 -		53 7/25 -	618 7/31 -			
			49 7/13 -	2096 7/13 -	18 7/10 -	6 7/19 ⊕	452 7/16 -	315 8/7 -	35 7/26 -	4 7/21 -	2 7/30 ⊕		315 8/28 -		792 7/25 ⊕	52 7/29 -			
			49 7/15 -	5 7/13 -	18 7/19 -	2096 7/18 -	714 7/17 -	2096 8/7 -	35 7/27 -	35 7/21 -	7 7/29 -		315 8/30 -		61 7/25 -	13 7/31 -			
			49 7/16 -	2 7/12 -	77 7/10 -	5 7/7 -	AUGUST	618 8/7 -	618 7/26 -	35 7/22 -	7 7/30 -		315 8/31 -			53 7/31 -			
			60 7/11 -	4 7/12 -	6 7/10 -	2 7/8 -	267 8/5 -	618 8/15 -	7 7/27 -	35 7/23 -	46 7/29 -		49 8/1 -			34 7/28 -			
			60 7/14 -	4 7/13 -	2096 7/10 -	4 7/8 -	267 8/7 -	618 8/16 -	46 7/26 -	618 7/21 -	792 7/30 ⊕		49 8/24 -			61 7/31 -			
			60 7/15 -	35 7/12 -	2096 7/19 -	4 7/19 -	267 8/24 -	7 8/15 -	13 7/26 ⊕	46 7/20 -	714 7/30 -		49 8/25 -			AUGUST			
			60 7/16 -	35 7/13 -	5 7/10 -	35 7/8 -	267 8/27 -	7 8/17 -	53 7/27 -	52 7/21 ⊕	34 7/30 -		49 8/27 -			267 8/2 -			
			10 7/13 -	35 7/15 -	5 7/9 -	35 7/9 -	8 8/6 -	714 8/7 -	792 7/27 -	52 7/23 ⊕	464 7/30 -		49 8/31 -			315 8/1 -			
			10 7/14 -	48 7/12 -	2 7/10 -	48 7/17 -	8 8/8 -		714 7/27 ⊕	52 7/24 -	AUGUST		22 8/26 -			315 8/2 -			
			10 7/16 -	48 7/13 -	4 7/10 -	618 7/19 -	8 8/25 -	315 9/2 -	714 7/29 -	13 7/18 -	5 8/1 -		18 8/25 -			1 8/1 -			
			18 7/13 -	618 7/12 -	4 7/10 -	7 7/7 -	8 8/28 -	315 9/4 -	464 7/26 -	13 7/19 -	46 8/1 -		77 8/24 -			60 8/1 -			
			77 7/14 -	7 7/14 -	35 7/10 -	46 7/8 -	8 8/30 -	49 9/2 -	61 7/27 -	13 7/20 -	792 8/1 -		77 8/27 -			10 8/1 -			
			77 7/16 -	46 7/15 -	48 7/10 -	52 7/8 -	315 8/8 -	49 9/4 -	AUGUST	13 7/22 ⊕			77 8/30 -			10 8/2 -			
			77 7/30 -	52 7/13 -	48 7/19 -	53 7/8 -	315 8/12 -	49 9/5 -	267 8/15 -	53 7/21 -			2096 8/25 -			77 8/1 -			
			6 7/13 -	52 7/15 -	618 7/10 -	792 7/8 -	1 8/8 -	60 9/1 -	8 8/14 -	53 7/23 -			4 8/24 -			77 8/2 -			
			6 7/15 -	13 7/12 -	53 7/13 -	464 7/7 -	1 8/10 -	60 9/3 -	8 8/18 ⊕	792 7/22 ⊕			4 8/28 -			2096 8/2 -			
			2096 7/5 -	452 7/12 -	792 7/20 -	464 7/9 -	49 8/6 -	60 9/4 -	315 8/14 -	714 7/20 -			4 8/31 -			5 8/2 ⊕			
			2096 7/6 -	792 7/15 -	AUGUST	AUGUST	49 8/7 -	4 9/4 -	49 8/13 -	34 7/24 -			35 8/25 -			2 8/1 -			
			2096 7/7 -	464 7/16 -	315 8/5 -	267 8/3 -	49 8/9 -	4 9/5 -	49 8/15 -	34 7/25 -			35 8/31 -			2 8/2 -			
			5 7/11 -		5 8/7 -	267 8/16 -	49 8/10 -	35 9/2 -	22 8/13 -	464 7/21 -			48 8/25 -			35 8/1 -			
			5 7/14 -		4 8/11 -	267 8/7 -	49 8/12 -	48 9/4 -	22 8/14 -	AUGUST			618 8/24 -			48 8/2 -			
			2 7/13 -		7 8/11 -	8 8/12 -	10 8/6 -	792 9/1 -	10 8/14 -	267 8/4 -			7 8/1 -			618 8/1 -			
			2 7/15 -		61 8/9 -	8 8/16 -	10 8/10 -	714 9/1 -	18 8/13 -	267 8/19 -			13 8/25 ⊕			618 8/2 -			
			2 7/16 -			315 8/16 -	10 8/2 ⊕		77 8/13 -	267 8/21 -			792 8/26 -			13 8/2 -			
			4 7/15 -			1 8/12 -	18 8/11 -		77 8/14 -	267 8/22 -			792 8/28 -			53 8/2 -			
			4 7/16 -			1 8/15 ⊕	77 8/6 -		77 8/18 -	267 8/23 -			792 8/30 -			792 8/2 -			
			48 7/15 -			49 8/16 -	77 8/7 -		2096 8/18 -	8 8/4 -			714 8/26 -			714 8/1 -			
			618 7/13 -			49 8/7 -	77 8/8 -		4 8/14 -	315 8/4 -			714 8/28 -			714 8/2 -			
			618 7/15 -			60 8/6 -	77 8/9 -		35 8/4 -	315 8/19 -			714 8/30 -			61 8/2 -			
			7 7/11 -			60 8/7 -	77 8/11 -		35 8/17 -	315 8/20 -			34 8/1 -						
			312 7/4 -			22 8/16 -	77 8/12 -		618 8/14 -	315 8/22 -			34 8/24 -						
			312 7/13 -			22 8/17 -	2096 8/5 -		618 8/19 -	1 8/4 -			61 8/1 -						
			46 7/11 -			10 8/16 ⊕	2096 8/1 -		7 8/13 ⊕	49 8/4 -			61 8/28 -						
			46 7/13 -			10 8/17 -	2096 8/2 ⊕		46 8/14 -	49 8/19 -			61 8/30 -						
			52 7/4 -			18 8/16 -	2096 8/3 -		53 8/18 -	49 8/20 -			61 8/31 -						
			52 7/14 -			18 8/17 -	2096 8/6 -		792 8/14 -	60 8/19 -									
			52 7/17 -			77 8/14 -	2096 8/7 -		34 8/14 -	60 8/20 -									
			13 7/4 -			77 8/16 -	5 8/5 -		34 8/18 -	60 8/22 -									
			13 7/14 -			618 8/18 -	5 8/8 -		61 8/14 -	22 8/19 -									
			13 7/17 -			13 8/15 -	4 8/7 -		61 8/15 -	22 8/20 -									
			452 7/3 -			13 8/16 -	4 8/9 -			22 8/22 -									
			452 7/5 -			13 8/18 -	4 8/12 -			10 8/4 -									
			792 7/16 -			53 8/5 -	4 8/15 -			18 8/6 -									
			714 7/5 -			53 8/16 -	4 8/17 -			18 8/21 -									
			34 7/4 -			792 8/15 -	35 8/5 -			18 8/23 -									
			SEPTEMBER			34 8/16 -	35 8/6 -			77 8/4 -									
			267 9/19 -			34 8/17 -	35 8/10 -			77 8/5 -									
			267 9/20 -			61 8/16 -	35 8/11 -			77 8/9 -									
			267 9/21 -			61 8/18 -	35 8/15 -			77 8/21 -									
			267 9/25 -				48 8/5 -			77 8/23 -									
			267 9/27 -				48 8/8 -			6 8/3 -									
			315 9/6 -				48 8/11 -			2096 8/3 -									
			315 9/10 -				618 8/5 -			2096 8/19 -									
			315 9/12 -				618 8/8 -			2096 8/21 -									
			315 9/14 -				618 8/9 -			2096 8/22 -									
			315 9/17 -				618 8/11 -			2096 8/23 -									
			315 9/20 -				618 8/12 -			5 8/4 ⊕									
			315 9/21 -				7 8/6 -			4 8/20 -									
			60 9/22 -				7 8/8 -			35 8/21 -									
			60 9/25 -				46 8/6 -			48 8/3 -									
			2096 9/9 -				46 8/8 -			48 8/19 -									
			2096 9/10 -				46 8/10 -			48 8/21 -									
			2096 9/12 -				46 8/11 -			48 8/23 -									
			2096 9/18 -				46 8/12 -			618 8/4 -									
			2096 9/20 -				46 8/15 -			618 8/20 -									
			4 9/9 -				13 8/6 -			618 8/22 -									
			4 9/10 -				13 8/8 -			7 8/4 ⊕									
			4 9/12 -				13 8/9 -			7 8/19 -									
			4 9/16 -				13 8/13 -			7 8/21 -									
			4 9/21 -				53 8/6 -			46 8/4 -									
			4 9/23 -				53 8/9 -			46 8/7 -									
			48 9/16 ⊕				53 8/10 -			13 8/3 -									
			53 9/25 -				53 8/12 -			13 8/5 -									
			714 9/21 ⊕				53 8/13 -			13 8/20 -									
			34 9/8 -				792 8/9 -			53 8/5 -									
			464 9/1 -				792 8/11 -			53 8/20 -									
			464 9/3 ⊕				792 8/12 ⊕			792 8/5 -									
			464 9/6 ⊕				792 8/7 -			792 8/20 -									
			61 9/8 -				792 8/8 -			792 8/21 -									
							714 8/6 -			792 8/23 -									
							714 8/9 -			792 8/24 -									
							714 8/11 -			714 8/4 -									
							714 8/13 ⊕			34 8/3 -									
							714 8/15 -			34 8/20 -									
							714 8/17 -			34 8/22 -									
							34 8/5 -												
							34 8/13 -												
							464 8/6 -												
							464 8/11 -												
							61 8/5 -												
							61 8/11 -												
							61 8/12 -												

this experiment during July, August and the first part of September 32 were found to contain the organism, detected in hens Nos. 10, 18, 6, 5, 2, 52, 13, 792, 8, 1, 2096, 7, 714, 267, 48 and 464. With hen No. 10, 11 eggs were tested, covering a laying period of seventeen days, before the organism was detected. With hen No. 18, 8 eggs were tested, covering a laying period of sixteen days prior to its detection. With hen No. 6, 5 eggs were tested, covering a laying period of six days. With hen No. 5, 12 eggs were tested, covering a laying period of twenty days. With the other 11 infected birds it varied from the 6th to the 21st egg laid before *Bacterium pullorum* was detected for the first time, and the laying periods varied from eight to sixty-one days (see Table 5 on page 10).

It is interesting to note at this point that all the hens, except 22, which were received from the Maryland Experiment Station, previously inoculated intravenously with a pure culture of *Bacterium pullorum*, after two years, showed positively the ovarian infection. This is in full agreement with the work of Dr. Jones, — that it is possible to cause local infection and cause such infection through the blood system.

As stated before, it has not been the primary object of these egg tests to make an exhaustive study of the value of diagnosis of ovarian infection by this method, but it has been of importance to determine by it if possible the number of these hens infected, to use as a check on the work on agglutination which was to follow.

Therefore, according to these tests hens Nos. 10, 8, 6, 5, 2, 52, 13, 792, 714, 8, 1, 2096, 7, 48 and 464 are all infected hens, the organism having been demonstrated conclusively in their eggs. It should also be stated that prior to starting experiments with these birds the organism had been detected in hen No. 267. From our work just cited it can be seen that in those hens which did lay eggs containing *Bact. pullorum*, the elimination from the ovary was so irregular that it would be impossible to make a diagnosis in a short time.

Since there was at hand such good material for study it was considered of importance to study the macroscopic agglutination test, as suggested by Jones [1, 2], — as regards the practicability of the tests, the test fluids and important steps to be observed in making the diagnosis, — and to carry out the test with three laboratory technicians to determine the value of this macroscopic test as a laboratory procedure for the diagnosis of this infection in adult hens.

This test depends upon the specific agglutinin elaborated in the blood serum of hens harboring the organism. The test requires a test fluid containing a suspension of *Bacterium pullorum* in 0.85 per cent. salt solution, preserved with 0.5 per cent. carbolic acid, and the specific agglutinin, diluted in varying amounts from suspected individuals. The agglutinins act on dead as well as living organisms.

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[1] Jones, F. S.: Report, New York State Veterinary College for 1910–11, p. 76.

[2] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum*." Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485–495.

Table 5.

HEN NO.	No. OF EGGS LAID BEFORE B. PULLORUM WAS DETECTED	LAYING PERIOD IN DAYS
10	11	20
18	8	16
6	5	6
5	12	20
2	7	16
52	7	10
13	8	15
792	5	8
714	4	12
8	21	39
1	13	38
2096	21	33
7	11	24
48	19	58
464	12	61

From some preliminary tests it was found that the living test fluids gave little better results. For this reason it was decided to carry out our work, using the living organisms in preparing the various test fluids.

The Test Fluid.

Before preparing any of our test fluids for these macroscopic agglutination reactions, all strains of *Bacterium pullorum* were thoroughly tested out to establish their pathogenic powers. The *Bacterium pullorum* material had been isolated from 7 different sources, and was designated S_1 (Strain No. 1) S_2, S_3, S_4, S_5, S_6 and S_7, and represented cultures of *Bacterium pullorum* isolated by the author from chicks which had died of the disease from an infected flock of hens in western Massachusetts; from another chick, dead of the disease; from an infected flock of more than 400 hens from eastern Massachusetts; from a fresh egg laid by a hen in this infected flock; from the ovarian tissue of a badly infected hen in the State of Maryland; from a chick which had died after experimental inoculation with a pure culture isolated from ovarian tissue; from a strain isolated from Connecticut epidemics and furnished to the author three years ago by Dr. Rettger of Yale University. The last, or Strain No. 7, was recovered from a local epidemic. These strains were all carefully examined for purity, and after due time were obtained in a very active state of growth. Strain No. 4 was finally not used because it appeared to have lost so much of its virulence.

For testing the virulence of these 6 strains of *Bacterium pullorum* 154 day-old chicks, hatched July 10, 1913, were used. They were divided into 7 lots, 22 in each lot. Six of these sets were inoculated with *Bact. pullorum* and the seventh was used for control. The chicks were fed sterilized food and water and were retained in wire animal cages and brooded with stone jugs containing hot water. The litter used was fine shavings which had been sterilized and spread in a layer over floor of cages prior to putting the chicks in. Each chick in the lots to be infected received ¼ c.c. of a physiological saline suspension of the various strains of *Bacterium pullorum* subcutaneously. The control lot received ¼ c.c. sterile physiological salt solution administered in the same manner. Chicks in pen No. 1 were inoculated with S_1; chicks in pen No. 2, with S_2; chicks in pen No. 3, with S_3; chicks in pen No. 4, with S_5; chicks in pen No. 5, with S_6; chicks in pen No. 6, with S_7; and the chicks in pen No. 7 were the controls.

As soon as chicks died they were carefully autopsied and the liver, heart, unabsorbed yolk and calcar examined for presence of *Bacterium pullorum.* In Table 6 are arranged the mortality records which furnish the evidence of the pathogenicity of these various strains. From each chick, dead of the disease, cultures were retained, and in Table 6 P. signifies that the cultures were recovered from the respective organs in an absolutely pure state. Wherever there is a denotation N.P. it signifies that culture recovered was not pure. However, in no case did the contaminating factor so outgrow or obscure the colony of *Bacterium pullorum* but that it was possible to recover it from some of the tubes. At this point it is sufficient to say that the symptoms — pre-mortem and post-mortem findings of chicks dead of the disease — correspond with those previously studied by the author.[1]

After twenty-five days the tests were considered completed, and Strains Nos. 1, 2, 3, 5, 6 and 7 were all in perfect condition to continue the work with the agglutinations. Pen No. 7, the control lot, never showed any signs of disease, and until a few weeks ago (Dec. 1, 1913) 20 of the 22 were living, healthy, vigorous birds. Only two deaths occurred among the 22 control chicks; one was accidental and the other was killed on account of lameness.

Making the Test Fluid.

Slant agar tubes were inoculated with *Bact. pullorum* and grown in incubator at 38° C. for one or two days. The growth was then washed with carbolated salt solution (0.85 per cent. salt solution containing 0.5 per cent. carbolic acid). The whole volume of washed material should have a very definite cloudy appearance. This was put in the shaking machine and shaken for one-half hour and then passed through sterile absorbent cotton to strain out any clumps of bacteria which might remain. Care should always be observed not to prepare the suspension too thin. A good test fluid should be uniformly turbid. This should be retained on ice or in lower part of refrigerator.

Method of obtaining Blood Serum.

At first the method of cutting a spike of the comb was employed, but since the bird's blood coagulates so quickly if in contact with tissue this was found unsatisfactory. Then the method of cutting the wing vein was employed, and by working carefully with this method it was found to be suitable in every respect for drawing blood in 2 to 10 c.c. quantities, causing but little effect upon the bird. At first great care was used in cutting through the cutaneous tissue until the *vena ulnaris* was reached, and the tissue teased away to make a clean cutting surface for making the incision into the vein. By such treatment it was possible to get the blood under quite ideal conditions, but the bird was submitted to considerable discomfort. Finally it was found that the quicker the cut was made the better the results, and less discomfort for the individual. The procedure finally adopted for drawing about 6 c.c. of blood in a very short time, and one which appeared to cause the individual no apparent discomfort, nor disturb the egg laying later on, was carried out as follows: the bird was laid on its side and the wing laid out near the edge of the table and turned downward to afford a grade for the sample of blood to flow into test tube.

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[1] Gage, Geo. Edward: "Notes on ovarian infection with *Bacterium pullorum* (Rettger) in the domestic fowl." Journal Medical Research, Vol. XXIV., No. 3; N. S. Vol. XIX., No. 3; June, 1911, pp. 491-496.

TABLE 6.

Mortality Records of chicks on test to demonstrate pathogenicity of Bacterium pullorum S_1, S_2, S_3, S_5, S_6 and S_7

Pen no 1 - chicks inoculated subcutaneously with 0.25 c.c. physiological saline suspension Bact. pullorum Strain 1 22 in number.
(SEE LEGEND AT BOTTOM OF TABLE)

Chick No	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures purified and filed as No.
1	7-13-13	+ NP	+ P	–	–	H 1
2	7-13-13	+ N.P	+ NP	+ N.P.	+ N.P	H 2 L 3
3	7-13-13	+ P	+ P	+ NP	+ NP	H 4 L 5 U 6
4	7-14-13	+ N.P	+ N.P	+ P		U 7
5	7-14-13	+ P	+ NP	+ N.P	+ N.P	H 8 L 9
6	7-14-13	+ N.P.	+ N.P.	+ NP	–	H 10 L 11
7	7-14-13	+ P	+ P	+ NP	+ N.P.	H 12 L 13 U 14
8	7-14-13	+ N.P.	+ N.P.	+ NP	+ N.P.	L 15 U 16 C 17
9	7-14-13	+ P	+ P	+ NP	+ N.P.	H 18 L 19 U 20
10.	7-14-13	+ N.P.	+ N.P.	+ N.P	+ N.P.	L 21 U 22
11.	7-15-13	+ P	+ N.P	+ P	+ NP	H 23 L 24 U 25
12	7-15-13	+ N.P.	+ N.P	+ N.P	+ NP	H 26 L 27 U 28 C 29
13	7-15-13	+ P	+ P	+ P	+ N.P	H 30 L 31 U 32
14	7-16-13	+ NP	+ P.	+ N.P	+ N.P	L 33
15	7-16-13	+ NP.	+ N.P	+ N.P.		H 34' L 35 U 36
16	7-16-13	+ N.P	+ N.P.	+ N.P	+ N.P	H 37 L 38 U 39
17	7-16-13	– NP	– NP	+ NP		U 40
18	7-16-13	+ P	+ P	+ N.P	– NP	H 41 L 42 U 43
19	7-17-13	+ N.P.	+ N.P.			H 44 L 45
20						
21						
22						

Pen no 2 - chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact. pullorum Strain 2 22 in number

Chick No	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures purified and filed as No.
1	7-12-13	–	–	–	-	
2	7-14-13	– NP	+ N.P	+ P	– NP	L 46 U 47
3	7-14-13	+ N.P	+ N.P	+ NP	– N.P.	H 48 L 49 U 50
4	7-15-13	+ P	+ P	+ NP	+ N.P.	H 51 L 52 U 53
5	7-15-13	+ N.P	+ N.P	+ N.P	– NP	H 54 L 55 U 56
6	7-1- 13	I NP	+ P	+ NP	+ NP	L 57
7	7-16-13	+ NP	+ P	+ P		H 58 L 59 U 60
8	7-16-13	+ NP	+ NP	+ P	+ NP	H 61 L 62 U 63
9	7-16-13	+ NP	+ NP	+ P	+ NP	H 64 U 65
10	7-16-13	+ P	+ P	+ NP	+ NP	H 66 L 67
11	7-16-13	+ P	+ NP	+ P	+ P	H 68
12	7-17-13	+ NP	+ NP	?		U 69
13	7-17-13	+ P	+ P	+ NP	– NP	H 70 L 71 U 72
14	7-17-13	+ NP	+ NP			H 73
15	7-17-13	+ NP	+ NP	+ NP	+ NP	L 74 U 75 C 76
16	7-17-13	I	+ NP	+ NP	I NP	U 77
17	7-17-13	+ NP	+ P	+ P	+ NP	L 78 U 79
18	7-18-13	+ NP	+ NP	+ NP	+ NP	L 80 U 81
19	7-21-13	+ P	+ P	+ NP	+ NP	L 82
20	7-23-13	+ NP	– NP	+ NP	+ NP	H 83
21						
22						

Pen no 3. - chicks inoculated subcutaneously with 0.25 c.c. physiological saline suspension Bact. pullorum Strain 3 22 in number

Chick No	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures purified and filed as No.	Chick No
1	7-12-13	–	–	–	–		1
2	7-14-13	– NP	+ NP	+ P	+ NP	H 84 L 85 U 85	2
3	7-14-13	– NP	+ P	+ NP	+ NP	L 87	3
4	7-14-13	– NP	+ NP	+ NP	+ NP	H 88 L 89	4
5	7-15-13	– NP	+ P	+ NP	+ NP	H 90 L 91 U 92	5
6	7-15-13	+ P	+ NP	+ NP	+ NP	H 93 L 94 C 95	6
7	7-16-13	+ NP	+ NP	+ NP	+ NP	U 96	7
8	7-16-13	+ NP	+ P	+ NP	+ NP	L 97	8
9	7-16-13	+ NP	+ NP	+ NP	+ NP	H 98 L 99 U 100	9
10	7-16-13	– NP	?	+ NP	?	H 101 U 102	10
11	7-16-13	+ NP	+ NP	+ NP	+ NP	H 103 L 104 U 105	11
12	7-16-13	+ P	+ P	+ P	+ NP	H 106 L 107 U 108 C 109	
13	7-17-13	+ P	+ NP	+ NP	+ NP	H 110 L 111 U 112	
14	7-17-13	?	+ P	+ NP	+ NP	L 113 U 114	
15	7-17-13	– NP	+ NP	+ NP	+ NP	L 115 U 116	
16	7-17-13	+ NP	–	+ NP	+ NP	H 117	
17	7-17-13	+ P	+ NP	+ NP	+ NP	H 118 L 119	
18	7-19-13	– NP	+ NP	+ NP	+ NP	H 120	
19	7-22-13	+ P	+ P	+ P	+ NP	H 121 L 122 U 123	

Pen no 4 - chicks inoculated subcutaneously with 0 25 c.c physiological saline suspension Bact pullorum Strain 5. 22 in number

Chick No	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Culture purified and filed as No.
1	7-13-13	– NP	+ NP	– NP	?	L 124
2	7-14 13	+ NP	+ NP	+ NP	+ NP	H 125 L 126 U 127 C 128
3	7-15 13	+ NP	+ NP	+ NP	+ NP	H 129 L 130
4	7-16-13	–	+ NP	–	+ NP	H 131 L 132 C 133
5	7-16-13	+ NP	+ P	+ NP	?	H 134 L 135 U 136
6	7-16-13	+ P	+ NP	+ P	+ NP	H 137 L 138 U 139 C 140
7	7-16-13	+ NP	+ NP	+ NP	+ NP	H 141 L 142 U 143 C 140
8	7-16 13	– NP	+ NP	+ NP	–	L 145 U 146
9	7-17-13	–	+ NP	+ NP	?	L 147 U 148
10	7-17-13	?	+ NP	+ NP	?	L 149 U 150
11	7-17-13	?	+ NP	+ P	+ NP	L 151 U 152 C 153

Pen no 5 - chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact. pullorum Strain 6 22 in number.

Chick No	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures purified and filed as No
1	7-12 13	+ P	+ NP	+ P	+ NP	H 154 L 155 U 156
2	7-13-13	+ P	+ NP	+ P	+ NP	L 157 U 158
3	7-14-13	+ NP	+ P	+ NP	+ P	L 159 U 160
4	7-15-13	+ P	+ P	+ NP	+ P	L 161 U 162
5	7-15 13	+ P	+ P	+ P	+ P	H 163 L 164
6	7-15-13	+ P	+ P	+ P	+ P	H 165 L 166
7	7-15-13	+ P	+ NP	+ P	+	H 167 U 168
8	7-15 13	+ P	+ NP	+ P	+ NP	H 169 L 170 U 171 C 172
9	7-15-13	+ P	+ NP	+ P	+ NP	H 173 L 174 U 175
10	7-15-13	+ P	+ NP	+ P	+ NP	H 176 L 177 U 178
11	7-16-13	+ P	+ P	+ NP	+ NP	H 179 L 180 U 181
12	7-16 13	+ P	+ NP	+ P	+ NP	H 182 L 183
13	7-16 13	+ P	+ NP	+ P	+ NP	H 184 L 185 U 186
14	7-16 13	+ NP	+ NP	+ P	+ NP	U 187

Pen no 6 - chicks inoculated subcutaneously with 0 25 c.c physiological saline suspension Bact pullorum Strain 7, 22 in number

Chick No	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Culture purified and filed as No
1	7-13-13	+ NP	–	+ NP	?	H 188 U 189
2	7 14-13	+ NP	– NP	+ P	?	H 190 U 191
3	7-15 13	+ NP	+ NP	+ NP	+ NP	H 192 U 193
4	7 15 13	+ P	+ NP	+ NP	+ NP	H 194 L 195
5	7-16-13		+ P	+ P	· NP	L 196 U 197
6	7-16 13	+ NP	+ NP	+ NP	+ NP	L 198
7	7-16-13	–	– NP	+ P	+ NP	H 199 L 200 U 201 C 20
8	7-16-13	+ P	+ P	+ NP	+ NP	H 203 L 204 U 205
9	7-16-13	+ NP	+ NP	+ NP	+ NP	L 206 U 207
10	7-17-13	+ NP	+ NP	+ NP	?	H 208 U 209
11	7-17-13		+ NP	+ NP	+ NP	L 210 U 211
12	7-18-13	+	+ NP	+ NP		L 212 U 213
13	7-21-13	+ NP	+ NP	+ NP		H 214 L 215 U 216
14	7-25-13	–	–	–	–	
15	7-28-13	–	+ P		–	L 217

LEGEND
+ = Bacterium pullorum detected
– = Bacterium pullorum not detected
P = signifies isolated in absolutely pure culture
NP = signifies culture showed some sign of contamination
H = culture isolated from heart
L = Culture recovered from liver
U = Culture isolated from unabsorbed yolk
C = culture recovered from caeca. (signifying from either right or left)

The finger of the operator was placed under the *vena ulnaris*, between the ulnal and radial bones near the distal ends, and pressed until the vein by distention shows plainly. Then having sterilized the part, and using sterile fine scissors, a cut was made through the cutaneous tissue into the vein, making a short cut longitudinally. The blood will flow out in large drops, and can be easily collected into a test tube, and by using a pledget of cotton moistened with 1–40 carbolic acid the flow of blood can be quickly stopped, and then by placing a dry piece of cotton over the incision and closing the wing down tightly, in a few minutes the individual may be returned to the pen. Blood thus obtained is allowed to clot, and the serum is later drawn off as a straw-colored supernatant fluid. This is then diluted with carbolated salt solution to the usual stock dilution 1–20.

Making the Agglutination Test.

Small test tubes 4 inches long and $\frac{1}{2}$-inch calibre were used. During some of our preliminary tests 3 c.c. test fluid was used as suggested by Jones,[1] but it was found after several sets had been tried out that 1.5 c.c. of the test fluid gave equally good results. The dilutions used most were 1–100, 1–200 and 1–500, but in some of the work test dilutions from 1–100 to 1–5,000 were used and made as follows: all sera were diluted 1–20, and then by a simple algebraic calculation the amount of diluted (1–20) serum necessary to add to 1.5 c.c. test fluid to make a desired dilution was determined. For example, 1.5 c.c. test fluid + .3 c.c. (1–20 serum) = dilution 1–100 desired. The following amounts of diluted 1–20 serum were added to 1.5 c.c. test fluid to make required dilutions: —

1– 100 = .3 c.c. diluted serum 1–20.
1– 200 = .15 c.c. diluted serum 1–20.
1– 300 = .099 c.c. diluted serum 1–20.
1– 400 = .075 c.c. diluted serum 1–20.
1– 500 = .06 c.c. diluted serum 1–20.
1– 800 = .037 c.c. diluted serum 1–20.
1–1,000 = .03 c.c. diluted serum 1–20.
1–1,200 = .025 c.c. diluted serum 1–20.
1–1,500 = .019 c.c. diluted serum 1–20.
1–1,800 = .016 c.c. diluted serum 1–20.
1–2,000 = .015 c.c. diluted serum 1–20.
1–2,500 = .012 c.c. diluted serum 1–20.
1–3,000 = .009 c.c. diluted serum 1–20.
1–4,000 = .007 c.c. diluted serum 1–20.
1–5,000 = .006 c.c. diluted serum 1–20.

Three sets of graduated pipettes were used, the first, a 5 c.c. graduated to $\frac{1}{10}$ c.c.; the second, graduated to $\frac{1}{100}$ c.c. The pipette graduated to $\frac{1}{100}$ c.c. was used to make dilutions up to 1–500, and for dilutions 1–500 to 1–5,000 one divided into $\frac{1}{1000}$ of c.c. was employed. After having made the desired dilution and thoroughly shaken each tube to afford a complete mixture of the agglutinative sera and *Bacterium pullorum* all was placed in the bacteriological incubator at 38° and readings made of the macroscopic agglutinative picture at the end of twenty-four, forty-eight and seventy-two hours. All tests were controlled, *i.e.*, test fluid and agglutinative sera.

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[1] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum*." Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485-495.

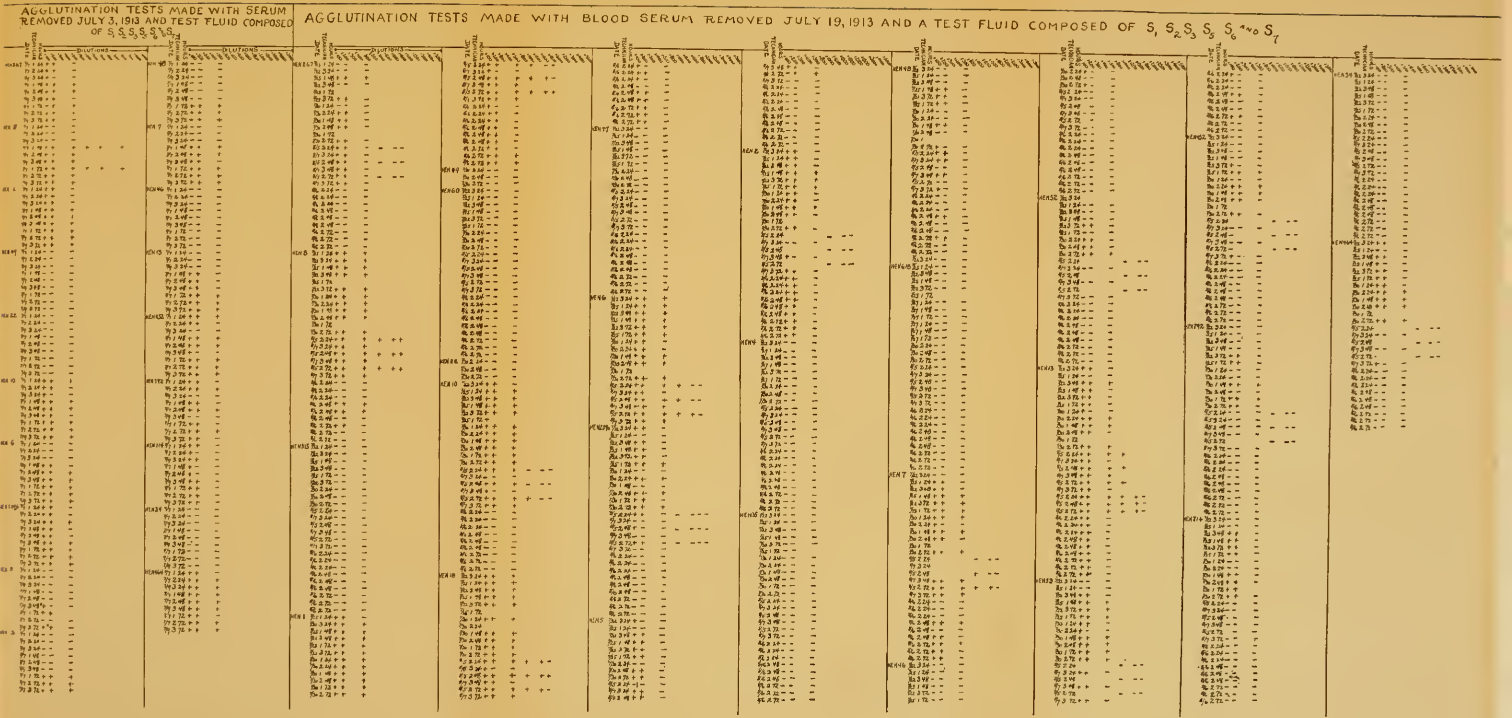
A positive macroscopic agglutination reaction is evident when the formation of fine, flake-like masses settle to the bottom of the tube into uneven heaped-up masses at the bottom and sides, leaving the supernatant fluid clear. This reaction is usually very prompt, and with sera of marked potency it is very clear and definitely defined. Controls should always be kept for check of test fluid, and check of diluted serum in carbolated salt solution.

The test fluid used for our work at first was composed of the 6 tested strains of *Bacterium pullorum* preserved by 0.5 per cent. carbolic acid and kept on ice. The serum was used continuously until no positive reactions would result in a serum known to be positive, and from this it was possible to determine about how long a serum could be retained under proper conditions and be in an active state for use in making the test.

In tables 7 and 8 which follow can be seen the results of the macroscopic tests on the birds carried out by three different technicians working independently. The technician is denoted in the column of that legend as 1, 2 and 3. It is indeed interesting to note that the work of the three technicians checks very well, and from the summary of the work of each no difference ever arose as to whether a bird was or was not a reactor. Hens Nos. 267, 8, 1, 10, 6, 2096, 10, 18, 6, 2, 48, 7, 13, 53, 792, 714, 464 and 61 were all proven by all three technicians to be infected hens, having the agglutinin present, varying in its powers to cause agglutination of *Bacterium pullorum.* From tables 7 and 8 it can be seen that with the results in the agglutination work, especially the tests made with the blood drawn on July 19, and with the serum of hens Nos. 267, 2, 10, 2096, 5, 2, 48, 52, 53, 452, 792, 714 and 464, the serum reactions were consistent with the three technicians until the seventeenth or eighteenth days, when the reactions began to vary considerably. This is indeed an interesting feature in favor of the test, and it is possible, under better conditions of preservation, that it may be kept longer. After the hundreds of tests made in this laboratory it would be safe to state that properly preserved and cooled agglutinative sera may be retained in a good state for subsequent tests for as long as two weeks. On the other hand, a carefully prepared test fluid, made from newly incubated cultures of *Bact. pullorum,* and suspended in 0.85 per cent. physiological saline solution containing 0.5 per cent. phenol, if retained on ice will remain in good condition for making the tests even after two months.

In some instances a serum retained for three weeks, when used by one technician on the 6th of August reacted, and had lost its agglutinative powers on the 7th when used by another technician. At the beginning

TABLE 7.



AGGLUTINATION TESTS MADE WITH SERUM REMOVED JULY 3, 1913 AND TEST FLUID COMPOSED OF S_1 S_2 S_3 S_5 S_6 AND S_7

AGGLUTINATION TESTS MADE WITH BLOOD SERUM REMOVED JULY 19, 1913 AND A TEST FLUID COMPOSED OF S_1 S_2 S_3 S_5 S_6 AND S_7

DATE
TECHNICIAN
HOURS
DILUTIONS

TABLE 8.

AGGLUTINATION TESTS MADE WITH BLOOD SERUM REMOVED AUG 11, 1913.
AND A TEST FLUID COMPOSED OF S_1, S_2, S_3, S_5, S_6, AND S_7.

	DATE	TECHNICIAN	HOURS	DILUTIONS 1:10	1:20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HEN 267	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	+			-		-								
	8/19	2	48	+	+			-		-								
	8/19	2	72	+	+			-		-								
	8/20	1	24	+	+			+	+	+								
	8/20	2	24	+	-			-		-								
	8/20	1	48	[illegible]														
	8/20	2	48	+	+			-		-								
	8/20	1	72	+	+			-	-	-								
	8/20	2	72	+	+			+		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-						
	8/25	2	72	+	+			-		-		-						
HEN 8	8/12		24															
	8/12		48															
	8/12		72															
	8/16	2	24	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/19	2	24	+	+	+	+	+	+	+								
	8/16	2	48	+	+	+	+	+	+	+								
	8/19	2	72	+	+	+	+	+	+	+								
	8/20	1	24	+	+	+	+	+	+	+								
	8/20	2	24	+	+	+	+	+	+	+								
	8/20	1	48	+	+	+	+	+	+	+								
	8/20	2	48	+	+	+	+	+	+	+								
	8/20	1	72	+	+	+	+	+	+	+								
	8/20	2	72	+	+	+	+	+	+	+								
	8/25	2	24	+	+	+	+	+	+	+	+	+						
	8/25	2	48	+	+	+	+	+	+	+	+	+						
	8/25	2	72	+	+	+	+	+	+	+	+	+						
HEN 315	8/13	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	72															
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-	-	-	-	-	-	-	-						
	8/17	1	72	-	-	-	-	-	-	-	-	-						
	8/19	2	72	-	-	-	-	-	-	-	-	-						
	8/20	1	24	-	-	-	-	-	-	-	-	-						
	8/20	2	24	-	-	-	-	-	-	-	-	-						
	8/20	1	48															
	8/20	2	48	-	-	-	-	-	-	-	-	-						
	8/20	1	72															
	8/20	2	72	-	-	-	-	-	-	-	-	-						
	8/25	2	24	-	-	-	-	-	-	-	-	-						
	8/25	2	48	-	-	-	-	-	-	-	-	-						
	8/25	2	72	-	-	-	-	-	-	-	-	-						
HEN 1	8/12	2	24	-	-	-	-	-	-	-	-	-						
	8/12	2	48	-	-	-	-	-	-	-	-	-						
	8/12	2	72	+	+	+	+	+	+	+	-	-						
	8/17	1	24	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/19	2	24															
	8/17	1	48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	8/19	2	48	+	+	+	+	+	+	+								
	8/17	1	72															
	8/19	2	72	+	+	+	+	+	+	+								
	8/22	1	24	+	+			+	+	+								
	8/20	2	24	+	+			+										
	8/22	1	48	+	+			+	+	+								
	8/20	2	48	+	+			+		+								
	8/22	1	72															
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+								
	8/25	2	48	+	+			+		+		+						
	8/25	2	72	+	+			+		+		+	-	-				
HEN 49	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-				
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-				
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-				
	8/16	2	24	-	-	-	-	-	-	-	-	-	-	-				
	8/16	2	48	-	-	-	-	-	-	-	-	-	-	-				
	8/16	2	72	-	-	-	-	-	-	-	-	-	-	-				
	8/19	2	24	-	-			-		-								
	8/19	2	48	-	-			-		-								
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-								
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 60	8/13	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	72															
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-	-	-								
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-			-		-								
	8/17	1	72															
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-								
	8/25	2	48	-	-			-		-								
	8/25	2	72	-	-			-		-								
HEN 22	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-		-								
	8/19	2	48	-	-			-		-								
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-		-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 10	8/12	2	24															
	8/12	2	48															
	8/12	2	72															
	8/16	2	24	+	+	+	-	-	-	-	-	-	-	-				
	8/16	2	48	+	+	+	+	-	-	-	-	-	-					
	8/16	2	72	+	+	+	+	+	-	-	-	-	-					
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	1	24	+	+			+	+	+								
	8/20	2	24	+	+			+		-								
	8/20	1	48	+	+			+	+	+								
	8/20	2	48	+	+			+		+								
	8/20	1	72	+	+			+	+	+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+		+						
	8/25	2	72	+	+			+		+		+						
HEN 18	8/13	2	24															
	8/13	2	48															
	8/13	2	72															
	8/19	2	24	-	-			-		-								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/17	1	24	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
	8/17	1	48	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
	8/20	1	24	+	+				+		+							
	8/20	2	24	+	+			+			+							
	8/20	1	48															
	8/20	2	48	+	+			+		+								
	8/20	1	72	+	+			+	+	+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+		+	-	-				
	8/25	2	72	+	+			+		+		+	-	-				
HEN 77	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-		-								
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-			-		-								
	8/17	1	72															
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48															
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-						
	8/25	2	72	-	-			-		-		-						
HEN 6	8/13	2	24	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/16	2	24	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	1	24	+	+			+	+	+								
	8/20	2	24	+	+			-		-								
	8/20	1	48	+	+			+	+	+								
	8/20	2	48	+	+			+		-								
	8/20	1	72	+	+													
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+	+	+						
	8/25	2	72	+	+			+		+	+	+						
HEN 204	8/12	2	24	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	-	-		-	-	-								
	8/19	2	48	+	-	-		-	-	-								
	8/19	2	72	+	-	-		-	-	-								
	8/20	1	24	+	+			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	+	+			+	-	-								
	8/20	2	48	-	-			-		-								
	8/20	1	72	+	+			+	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-	-	-				
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-										
HEN 2	8/16	2	24	+	+	+												
	8/16	2	48	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	2	24	+	+			+		+								
	8/22	2	24	+	+			+	+	-								
	8/20	2	48	+	+			+		+								
	8/22	1	48	+	+			+	+	-								
	8/20	2	72	+	+			+		+								
	8/22	1	72															
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+		+						
	8/25	2	72	+	+			+		+		+	-	-				
HEN 4	8/13	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/17	1	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/20	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/20	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-		
	8/20	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-		
	8/20	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-		
	8/20	1	72	-	-	-	-	-	-	-	-	-	-	-	-	-		
	8/20	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-		
	8/25	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-		
	8/25	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-		
	8/25	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-		
HEN 35	8/13	2	24	-	-	-	-	-	-	-	-	-	-	-		-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-		-	-	-
	8/13	2	72															
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-		-								
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-			-		-								
	8/19	1	72															
	8/19	2	72	-	-			-		-	-	-						
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-														
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-								
	8/25	2	48	-	-			-		-								
	8/25	2	72	-	-			-		-								
HEN 48	8/16	2	24	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	1	24	+	+			-	-	-								
	8/20	2	24	+	-			-	-	-								
	8/20	1	48	+	+			+	-	-								
	8/20	2	48	+	-			-		-								
	8/20	1	72	+	+			+	-	-								
	8/20	2	72	+	+			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 618	8/13	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/13	2	72															
	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-	-		-		-								
	8/17	1	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	48	-	-			-										
	8/17	1	72															
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48															
	8/20	2	48	-	-			-		-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
HEN 7	8/12	2	24	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
	8/16	2	48	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
	8/16	2	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	1	24	+	+			+	+	+								
	8/20	2	24	+	+			+		+								
	8/20	1	48	+	+			+	+	+								
	8/20	2	48	+	+			+		+								
	8/20	1	72	+	+			+	+	+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+		+						
	8/25	2	48	+	+			+		+		+	-	-				
	8/25	2	72	+	+			+		+		+	-	-				
HEN 46	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-			-		-								
	8/19	2	48	-	-			-		-								
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-	-	-								
	8/20	1	72	-	-			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 13	8/17	1	24	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/19	2	24	+	+			+		+								
	8/17	1	48	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-
	8/19	2	48	+	+			+		+								
	8/17	1	72															
	8/19	2	72	+	+			+		+								
	8/20	2	24	+	+			-		-								
	8/20	1	24	+	+			+	+	+								
	8/20	1	48	+	+			+	+	+								
	8/20	2	48	+	+			+		+								
	8/20	1	72	+	+			+	+	+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+								
	8/25	2	48	+	+			+		+	+	+	-	-				
	8/25	2	72	+	+			+		+	+	+	-	-				
HEN 53	8/19	2	24	-	-			-		-								
	8/19	2	48	+	+			+		+								
	8/19	2	72	+	+			+		+								
	8/20	2	24															
	8/20	2	48	+	+			+		+								
	8/20	2	72	+	+			+		+								
	8/25	2	24	+	+			+		+	-	-						
	8/25	2	48	+	+			+		+		+						
	8/25	2	72	+	+			+		+		+						
HEN 792	8/20	1	24	+	+			+	-	-								
	8/20	2	24	-	-			-	-	-								
	8/20	1	48	+	+			+	+	+								
	8/20	2	48	-	-			-		-								
	8/20	1	72	+	+			-	-	-								
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 714	8/16	2	24	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	-		-		-									
	8/19	2	48	+	+			-		-								
	8/19	2	72	+	+			-		-								
	8/20	1	24	+	+			+	-	-								
	8/20	2	24	+	-			-		-								
	8/20	1	48	+	+			+	-	-								
	8/20	2	48	+	+			-		-								
	8/20	1	72	+	+			-	-	-								
	8/20	2	72	+	+			+		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	+	+			+		-		-	-	-				
	8/25	2	72	+	+			+		-		-	-	-				
HEN 34	8/12	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/12	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	-	-	-		-		-								
	8/19	2	48	-	-			-		-								
	8/19	2	72	-	-			-		-								
	8/20	1	24	-	-			-	-	-								
	8/20	2	24	-	-			-		-								
	8/20	1	48	-	-			-	-	-								
	8/20	2	48	-	-			-		-								
	8/20	1	72															
	8/20	2	72	-	-			-		-								
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				
HEN 464	8/16	2	24	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	48	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/16	2	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	+	-	-	-	-	-								
	8/19	2	48	+	+	-	-	-	-	-								
	8/19	2	72	+	+			-		-								
	8/20	2	24	+	+			-		-								
	8/22	1	24	+	+			+	+	+								
	8/20	2	48	+	+			-		-								
	8/22	1	48	+	+			+	+	+								
	8/20	2	72	+	+			-		-								
	8/22	1	72															
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	+	+			-		-		-	-	-				
	8/25	2	72	+	+			-		-		-	-	-				
HEN 61	8/17	1	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8/19	2	24	+	+	-	-	-	-	-								
	8/17	1	48	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	8/19	2	48	+	+	-	-	-	-	-	-	-						
	8/17	1	72															
	8/19	2	72	+	+			-		-	-	-						
	8/20	1	24															
	8/20	2	24	+	+			-		-								
	8/20	1	48															
	8/20	2	48	+	+			-		-	-	-						
	8/20	1	72	+	+			+	+	-								
	8/20	2	72	+	+			+		-	-	-						
	8/25	2	24	-	-			-		-		-						
	8/25	2	48	-	-			-		-		-	-	-				
	8/25	2	72	-	-			-		-		-	-	-				

of this work, the serum was divided into three portions, to serve the technicians for independent work. The period of making tests for one technician often required more time to which the serum was submitted to laboratory temperature than that of another, and this in a way perhaps explains the keeping quality of one portion over another. However, one can see from the tests made that comparatively recently drawn sera carefully retained on ice yielded the best results.

Hens Nos. 315, 49, 60, 22, 77, 4, 35, 618, 46 and 34 never gave a positive reaction during this work, and the work of all three technicians checks in this respect. The serum of Nos. 2096, 52 and 464 gave varying reactions after long retention of serum, but no trouble was experienced by any of the workers in concluding that these birds either were harboring or had harbored *Bacterium pullorum*.

It may be stated here that under the conditions of the tests, if the test fluid is prepared uniformly, the test carefully carried out, the macroscopic agglutination test for detecting the virus of *Bacterium pullorum* has proven a good laboratory method as handled by three laboratory technicians in this laboratory during the past summer.

THE INFLUENCE OF TEST FLUIDS OF VARYING COMPOSITION (MONOVALENT AND POLYVALENT TEST FLUIDS).

For these tests an experiment was planned in which the serum was used, drawn on the 19th of July. The test fluid was composed of equal quantities of the different strains of *Bacterium pullorum* used throughout this work. In the first experiment or test a test fluid containing S_1 was used; in the second, a test fluid containing S_2; in a third, a test fluid containing equal quantities S_1 and S_2; in a fourth, a test fluid containing equal quantities S_1, S_2 and S_3; in a fifth, a test fluid containing equal quantities S_1, S_2 and S_7; in a sixth, a test fluid containing S_1, S_2, S_3 and S_5; in a seventh, a test fluid containing S_1, S_2, S_3, S_5 and S_6; and in an eighth, a test fluid containing S_1, S_2, S_3, S_5, S_6 and S_7. Various dilutions of the serum were used, the dilutions being made as before. In most cases readings were made after twenty-four, forty-eight and seventy-two hours' incubation.

An analysis of Table 9 shows that the serum from all hens which had previously agglutinated gave consistent positive results in all the sera. Sera from hens Nos. 2096, 452, 792 and 5 appeared to give better results with a test fluid containing several strains of the organism. Although some of the positive reactors showed good reactions with a monovalent test fluid, yet from the data at hand it may be stated as justified that a test fluid containing several different strains is best suited, under most conditions, in laboratory routine for making the test. Here it should be noted that none of the birds previously tested and found negative reacted when their serum was mixed with the test fluids of the various compositions.

The birds Nos. 58, 59, 62 and 63 were cocks. Of these, 59, 62 and 63 gave questionable reactions, and 58 gave a very weak or slight reaction of a positive nature. This is interesting, and it will require further study with this blood and work in connection with the autopsies of such birds to determine if the testicles of such individuals harbor the organism. The reactions with these birds were always very slight and questionable, and hardly comparable with the clearcut reactions exhibited when the blood serum from infected hens was used.

Comparison of Results of Macroscopic Agglutination Tests with Egg Analysis.

From the egg record table it can be seen that *Bacterium pullorum* was isolated 32 times from 619 eggs, and the individuals harboring such organisms, determined by eggs laid in July, were hen No. 10 on the 30th; hen No. 18 on the 26th; hen No. 6 on the 16th, 17th and 19th; hen No. 5 on the 30th; hen No. 2 on the 26th and 30th; hen No. 52 on the 21st and 23d; hen No. 13 on the 22d and 26th; hen No. 792 on the 23d, 25th and 30th; hen No. 714 on the 27th; and in August, besides these hens, hen No. 8 laid an egg containing *Bacterium pullorum* on the 18th; hen No. 1 on the 15th; hen No. 2096 on the 12th; hen No. 7 on the 4th and 13th; and in September, hen No. 48 on the 6th; hen No. 464 on the 13th and the 16th. Hen No. 452 died before an egg was laid which contained the organism, but at autopsy, when ova from this individual were crushed and inoculated into sterile bouillon and put in incubator at 38° C., the organism was detected later on the agar streaks. Hen No. 267 had previously been found to be infected by an egg test. Serum from all these hens caused agglutination of *Bacterium pullorum* test fluids, the results of three technicians being in agreement. The organism was not isolated from the ovarian tissue of hen Nos. 53 or 61, although both these hen's blood serum caused very active agglutination. This may suggest that the active infection had passed, and the agglutination test showed the results of the past active infection. On the other hand, hens Nos. 315, 49, 60, 22, 77, 4, 35, 618, 312, 46 and 34 never exhibited the organism in their eggs, nor did blood serum from these individuals cause agglutination of *Bact. pullorum*.

Post-mortem Findings of Some Reactors and Non-reactors.

After Oct. 1, 1913, hens Nos. 10, 5, 52, 1, 792, 464, 6 and 13, as reactors, were killed and the ovaries examined for the presence of *Bacterium pullorum*. All the reactors were not killed because it was desired to make further studies with the agglutinins. At the present time hens containing active agglutinative sera are retained at the laboratory under constant observation. Hen No. 10 at autopsy revealed a pathological ovary containing several retention cysts. *Bacterium pullorum* was isolated from this material by direct inoculation. Hen No. 52 at autopsy showed an ovary with retention cysts, and from material crushed in sterile bouillon *B. pullorum* was detected on all tubes streaked from such material. Then hens Nos. 1, 5, 6, 792, 464 and 13 were autopsied. All ovaries from these

TABLE 9.

AGGLUTINATION TESTS MADE WITH TEST FLUIDS OF DIFFERENT COMPOSITIONS

$S_1 - S_1 S_2 S_3 S_5 S_6 S_7$

TEST FLUID CONTAINS S_1

HEN NO	HRS	[illegible]	[illegible]	[illegible]	[illegible]
267	24	+	-	-	-
	48	+	+	-	-
	72	+	+	-	-
8	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
315	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
1	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
49	24	-	-	-	-
	48	-	-	-	-
	72	+	-	-	-
60	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
22	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
10	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
18	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
77	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
6	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
2096	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
2	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
4	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
35	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
48	24	-	-	-	-
	48	+	-	-	-
	72	+	+	+	+
618	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
7	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
46	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
13	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
53	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
792	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
714	24	+	-	-	-
	48	+	+	-	-
	72	+	+	-	-
34	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
464	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
61	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
58	24	-	-	-	-
	48	+?	-	-	-
	72	+?	-	-	-
59	48	-	-	-	-
	24	-	-	-	-
	72	-	-	-	-
62	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
63	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-

TEST FLUID CONTAINS S_2

HEN NO	HRS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
267	24				-	-	-
	48				-	-	-
	72				-	-	-
8	24				+	+	+
	48				+	+	+
	72				+	+	+
315	24		-	-			
	48		-	-			
	72		-	-			
1	24				+	-	-
	48				+	+	-
	72				+	+	+
60	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
10	24				-	-	-
	48				-	-	-
	72				+	-	-
18	24				+	+	-
	48				+	+	+
	72				+	+	-
77	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
6	24				+	-	-
	48				+	-	-
	72				+	+	-
2096	24				-	-	-
	48				-	-	-
	72				-	-	-
5	24		-	-			
	48		-	-			
	72		+	+			
2	24	+	+	+	-	-	-
	48	+	+	+	-	-	-
	72	+	+	+	-	-	-
4	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
35	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
48	24		-	-			
	48		-	-			
	72		-	-			
618	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
7	24	+	+	+	-	-	-
	48	+	+	+	+	-	-
	72	+	+	+	+	+	-
46	24		-	-			
	48		-	-			
	72		-	-			
52	24				-	-	-
	48				-	-	-
	72				-	-	-
13	24	+	+	+	+		
	48	+	+	+	+		
	72	+	+	+	+		
53	24	+	+	+	-	-	-
	48	+	+	+	-	-	-
	72	+	+	+	-	-	-
452	24	+	+	-	-	-	-
	48	+	+	-	-	-	-
	72	+	+	-	-	-	-
792	24				-	-	-
	48				-	-	-
	72				-	-	-
714	24		-	-			
	48		-	-			
	72		-	-			
34	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
464	24	+	+		-	-	-
	48	+	+		-	-	-
	72	+	+		-	-	-

TEST FLUID CONTAINS $S_1 + S_2$

HEN NO	HRS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
267	24	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
8	24	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	48	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
315	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	24	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
49	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	24	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
	72	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
18	24	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
	48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
77	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	24	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
2096	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	24	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
4	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
35	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
618	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	24	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
	48	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
	72	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
46	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	24	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-
792	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
714	24	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
464	24	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
61	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
58	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	24	+?	+?	+?	+?	-	-	-	-	-	-	-	-	-	-	-
	48	+?	+?	+?	+?	+?	-	-	-	-	-	-	-	-	-	-

TEST FLUID CONTAINS $S_1 + S_2 + S_3$

HEN NO	HRS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
267	24	+	+			
	72	+	+			
8	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
315	24	-	-	-	-	-
1	24	+	+	+	+	+
	48	+	+	+	+	+
49	24	-	-	-	-	-
	48	+	-	-	-	-
	72	+	+	+	+	-
60	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
22	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
10	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
18	24	+	+	+	+	+
	72	+	+	+	+	+
77	24	-	-	-	-	-
	72	-	-	-	-	-
6	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
2096	24	+	+	-	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
2	24	+	+	+	+	-
	48	+	+	+	+	-
4	24	+	+	+	-	-
	72	+	+	+	-	-
35	24	-	-	-	-	-
	72	-	-	-	-	-
48	24	+	+	-	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
618	24	+	-	-	-	-
	72	-	-	-	-	-
7	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
46	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
13	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
13	24	+	+	+	+	+
	48	+	+	+	+	+
792	24	+	+	+	-	-
	48	+	+	+	+	+
	72	+	+	-	-	-
714	24	+	+	+	-	-
	48	+	+	+	-	-
	72	+	+	-	-	-
34	24	-	-	-	-	-
	48	-	-	-	-	-
464	24	+	+	+	+	+
	48	+	+	+	+	+
61	72	+	+	+	+	-
58	24	+	+	-	-	-
	48	+	+	-	-	-
	72	+	+	-	-	-
59	24	-	-	-	-	-
	48	+?	-	-	-	-
	72	+?	-	-	-	-
62	24	+?	+?	+?	+?	-
	48	+?	+?	+?	+?	+
	72	+?	+?	+?	+?	-
63	24	+?	+?	+?	+?	-
	48	+?	+?	+?	+?	-
	72	+?	+?	+?	+?	-

TEST FLUID CONTAINS $S_1 + S_2 + S_7$

HEN NO	HRS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
315	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
618	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TEST FLUID CONTAINS $S_1 + S_2 + S_3 + S_5$

HEN NO	HRS	[illegible]	[illegible]	[illegible]	[illegible]
267	24	+	-	-	-
	48	+	+	-	-
	72	+	+	+	-
8	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
315	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
1	24	+	+	+	-
	48	+	+	+	+
	72	+	+	+	+
49	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
60	24	-	-	-	-
	48	-	-	-	-
	72	+	-	-	-
22	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
10	24	+	+	+	-
	48	+	+	+	+
	72	+	+	+	+
18	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
77	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
6	24	+	+	-	-
	48	+	+	+	-
	72	+	+	+	+
2096	24	-	-	-	-
	48	-	-	-	-
	72	+	+	+	+
2	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
4	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
35	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
48	24	-	-	-	-
	48	+	-	-	-
	72	+	+	-	-
618	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
7	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
46	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
13	24	+	+	-	-
	48	+	+	+	+
	72	+	+	+	+
53	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
792	24	-	-	-	-
	48	-	-	-	-
	72	+	+	+	-
714	24	+	-	-	-
	48	+	+	-	-
	72	+	+	+	-
34	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
464	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
61	24	+	+	-	-
	48	+	+	-	-
	72	+	+	+	-
58	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
59	24	+?	-	-	-
	48	+?	-	-	-
	72	+?	-	-	-
62	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
63	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-

TEST FLUID CONTAINS $S_1 + S_2 + S_3 + S_5 + S_6$

HEN NO	HRS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
267	24	+	-	-		
	48	+	+	-		
	72	+	+	-		
8	24	-	-	-		
	48	+	+	+		
	72	+	+	+		
315	24	-	-	-	-	-
	48	+	-	-	-	-
	72	+	-	-	-	-
1	24	+	+	-		
	48	+	+	+		
	72	+	+	+		
49	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
60	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
22	24	-	-	-		
	48	+	+	-		
	72	+	+	-		
10	24	+	-	-		
	48	+	-	-		
	72	+	+	+		
18	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
77	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
6	24	-	-	-		
	48	+	+	+		
	72	+	+	+		
2096	24	+	+	+		
	48	+	+	+		
	72	+	+	+		
5	24	-	-	-		
	48	+	-	-		
	72	+	+	-		
2	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
4	24	+	+	+	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
35	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
48	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
618	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
7	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
46	24	-	-	-	-	
	48	-	-	-	-	
	72	-	-	-	-	
13	24	+	+	+		
	48	+	+	+		
	72	+	+	+		
53	24	+	+	+	+	-
	48	+	+	+	+	+
	72	+	+	+	+	+
452	24	-	-	-		
	48	+	-	-		
	72	+	-	-		
792	24	-	-	-		
	48	-	-	-		
	72	+	+	-		
714	24	+	+	-		
	48	+	+	-		
	72	+	+	-		
34	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
464	24	+	+	+		
	48	+	+	+		
	72	+	+	+		
61	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
59	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
63	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-

HEN NO	HRS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
267	24	-	-	-	-	-
	48	-	-	-	-	-
	72	+	+	-	-	-
8	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
1	24	+	+	+	+	-
	48	+	+	+	+	+
	72	+	+	+	+	+
49	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
22	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
10	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
6	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
2096	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
2	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
48	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
46	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
13	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
792	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
714	24	-	-	-	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
34	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
464	24	-	-	-	-	-
	48	+	+	-	-	-
	72	+	+	-	-	-
58	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
62	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-

TEST FLUID CONTAINS $S_1 + S_2 + S_3 + S_5 + S_6 + S_7$

HEN NO	HRS	[illegible]	[illegible]	[illegible]
267	24	+	+	-
	24	+	+	-
	48	+	+	+
	48	+	+	+
8	24	-	-	-
	24	-	-	-
	48	+	+	+
	48	+	+	+
315	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
1	24	+	+	-
	24	+	-	-
	48	+	+	+
	48	+	+	-
49	24		-	-
	24	-	-	-
60	24	-	-	-
	24	-	-	-
	48	-	-	-
22	24	-	-	-
	24	-	-	-
10	24	+	+	-
	24	+	+	-
	48	+	+	+
	48	+	+	+
18	24	+	+	+
	24	+	+	+
77	24	-	-	-
	24	-	-	-
	48	-	-	-
6	24	-	-	-
	24	-	-	-
	48	+	+	-
2096	24	+	+	-
	24	+	+	-
	48	+	+	-
	48	+	+	-
5	24	-	-	-
	24	-	-	-
2	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
4	24	-	-	-
	24	-	-	-
	48	-	-	-
35	24	-	-	-
	24	-	-	-
	48	-	-	-
48	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
618	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
7	24	-	-	-
	24	-	-	-
	48	+	+	+
	48	+	+	+
46	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	+	-	-
52	24			
	24	-	-	-
	48	-	-	-
13	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	+	-	-
53	24	+	-	-
	24	+	-	-
	48	+	+	-
452	24	+	+	+
	24	+	+	-
	48	+	+	+
	48	+	+	+
792	24	+	+	-
	48	+	+	-
	24	+	+	+
	48	+	+	+
464	24	+	+	-
	24	+	+	+
	48	+	+	+

HEN NO	HRS	[illegible]	[illegible]	[illegible]
267	72	+	+	+
	72	+	+	+
	24	-	-	-
	24	-	-	-
8	72	+	+	+
	72	+	+	+
	24	+	+	+
	24	+	+	+
315	72	-	-	-
	72	-	-	-
1	72	+	+	+
	72	+	+	+
	24	+	+	-
	24	+	+	+
49	48	-	-	-
	48	-	-	-
60	48	-	-	-
	72	-	-	-
	72	-	-	-
22	48	-	-	-
	48	-	-	-
10	72	+	+	+
	72	+	+	+
	24	+	-	-
	24	+	+	+
18	48	+	+	+
	48	+	+	+
	72	+	+	+
77	48	-	-	-
	72	-	-	-
	72	-	-	-
6	48	+	+	+
	72	+	+	+
	72	+	+	+
2096	72	+	+	+
	72	+	+	+
	24	+	-	-
	24	-	-	-
5	48	-	-	-
	48	-	-	-
	72	-	-	-
2	72	+	+	+
	72	+	+	+
	24	+	+	-
	24	+	+	-
4	48	-	-	-
	72	-	-	-
	72	-	-	-
35	48	-	-	-
	72	-	-	-
	72			
48	72	+	+	+
	72	+	+	+
	24	-	-	-
	24	-	-	-
618	72	-	-	-
	24	-	-	-
	48	-	-	-
	72	-	-	-
7	72	+	+	+
	72	+	+	+
	24	+	+	-
	24			
46	72	+	-	-
	24	-	-	-
	24	-	-	-
	48	-	-	-
52	48	-	-	-
	72	+	+	-
	72	-	-	-
13	72	+	+	-
	72	+	+	-
	24	+	+	-
	24	-	-	-
53	48	+	+	+
	72	+	+	+
	72	+	+	+
452	72	+	+	+
	72	+	+	+
	24	-	-	-
	24	-	-	-
792	72	+	+	-
	72	+	+	+
	24	-	-	-
	24	-	-	-
464	48	+	+	+
	72	+	+	+
	72	+	+	-

HEN NO	HRS	[illegible]	[illegible]	[illegible]
267	48	+	+	+
	48	-	-	-
	72	+	+	-
8	48	+	+	+
	48	+	+	+
	72	+	+	+
315	24	-	-	-
	48	-	-	-
	72	+	+	-
1	48	+	+	+
	48	+	+	+
	72	+	+	+
	24	+	+	+
49	72	-	-	-
	24	-	-	-
60	24	-	-	-
	48	-	-	-
	72	-	-	-
22	72	+	+	-
	24	-	-	-
10	48	+	+	+
	48	+	+	+
	72	+	+	+
18	24	+	+	+
	24	-	-	-
	48	+	+	+
77	24	-	-	-
	48	-	-	-
	72	-	-	-
6	24	+	+	-
	24	+	+	-
	48	+	+	+
2096	48	+	+	-
	48	+	+	-
	72	+	-	-
	72	+	+	-
5	24	+	-	-
	24	-	-	-
	48	+	+	-
2	48	+	-	-
	48	+	+	+
	72	+	+	+
	72	+	+	+
4	24	-	-	-
	48	-	-	-
	72	-	-	-
35	24	-	-	-
	24	+	+	-
	48	-	-	-
48	48	-	-	-
	48	+	-	-
	72	+	+	-
	72	+	+	-
618	24	-	-	-
	48	-	-	-
	72	-	-	-
7	48	+	+	+
	48	+	+	+
	72	+	+	+
	72	+	+	+
46	48	-	-	-
	72	-	-	-
	72	-	-	-
52	24	+	+	-
	48	+	+	-
	72	+	+	+
13	48	+	+	+
	48	+	+	-
	72	+	+	-
	72	+	+	-
53	24	+	+	-
	24	+	-	-
	48	+	+	+
452	48	-	-	-
	48	-	-	-
	72	+	-	-
	72	+	+	+
792	48	-	-	-
	48	-	-	-
	72	+	-	-
	72	+	+	-
464	24	+	+	-
	24	+	-	-
	48	+	+	-

HEN NO	HRS	[illegible]	[illegible]	[illegible]
267	24	-	-	-
	24	+	+	-
	48	+	+	-
	48	+	+	-
8	24	+	+	+
	24	+	+	+
	48	+	+	+
	48	+	+	+
315	24	-	-	-
	48	-	-	-
	72	-	-	-
1	24	+	+	+
	48	+	+	+
	48	+	+	+
	72	+	+	+
49	48	-	-	-
	72	-	-	-
60	24	-	-	-
	48	-	-	-
	72	-	-	-
22	48	-	-	-
	72	-	-	-
10	24	+	+	+
	24	+	+	+
	48	+	+	+
	48	+	+	+
18	48	+	+	+
	72	+	+	+
	72	+	+	+
77	24	-	-	-
	48	-	-	-
	72	-	-	-
6	48	+	+	+
	48	+	+	+
	72	+	+	+
2096	24	-	-	-
	24	+	+	+
	48	-	-	-
	48	+	+	+
5	48	-	-	-
	72	+	+	-
	72	-	-	-
2	24	+	+	-
	24	+	+	-
	48	+	+	+
	48	+	+	+
4	24	-	-	-
	48	-	-	-
	72	-	-	-
35	48	-	-	-
	72	+	+	-
	72	-	-	-
48	24	-	-	-
	24	-	-	-
	48	+	+	+
	48	-	-	-
618	24	-	-	-
	48	-	-	-
	72	-	-	-
7	24	+	+	+
	24	+	-	-
	48	+	+	+
	48	+	+	-
46	24	+	-	-
	48	-	-	-
	72	+	-	-
52	24	-	-	-
	48	-	-	-
	72	-	-	-
13	24	+	-	-
	24	+	+	+
	48	+	+	+
	48	+	+	-
53	48	+	+	+
	72	+	+	+
	72	+	+	+
452	24	-	-	-
	24	+	+	+
	48	+	+	+
	48	+	+	-
792	24	-	-	-
	24	-	-	-
	48	+	+	+
	48	-	-	-
464	48	+	-	-
	72	+	+	-
	72	+	+	-

HEN NO	HRS	[illegible]	[illegible]	[illegible]
267	72	+	+	-
	24	-	-	-
	48	+	+	-
	72	+	+	-
8	72	+	+	+
	24	+	+	+
	48	+	+	+
	72	+	+	+
315	24	-	-	-
	24	-	-	-
	24	-	-	-
1	72	+	+	+
	24	+	-	-
	48	+	+	+
	72	+	+	+
60	24	-	-	-
	24	-	-	-
	24	-	-	-
10	72	+	+	+
	72	+	+	+
	24	-	-	-
	48	+	-	-
18	24	+	-	-
	48	+	+	-
	72	+	+	+
77	24	-	-	-
	24	-	-	-
	24	-	-	-
6	24	+	+	-
	48	-	-	-
	72	+	-	-
2096	72	+	+	-
	24	-	-	-
	48	-	-	-
	72	-	-	-
5	24	-	-	-
	48	-	-	-
	72	+	+	-
2	72	+	+	-
	24	-	-	-
	48	+	-	-
	72	+	+	+
4	24	-	-	-
	24	-	-	-
	24	-	-	-
35	24	-	-	-
	48	-	-	-
	72	-	-	-
48	72	+	-	-
	24	+	+	-
	48	+	+	-
	72	+	+	-
618	24	-	-	-
	48	-	-	-
	72	-	-	-
7	72	+	+	+
	24			
	48	+	+	+
	72	+	+	+
46	24	-	-	-
	48	-	-	-
	72	-	-	-
52	24	-	-	-
	24	-	-	-
	24	-	-	-
13	72	+	+	+
	24	+	+	-
	48	+	+	+
	72	+	+	-
53	24	+		-
	48	+	+	-
	72	+	+	-
452	72	+	+	-
	24	+	+	-
	48	+	+	-
	72	+	-	-
792	72	+	-	-
	24	-	-	-
	48	-	-	-
	72	-	-	-
464	24	+	+	-
	24	+	+	+
	48	+	+	+

HEN NO	HRS	[illegible]	[illegible]	[illegible]
267	24	-	-	-
	24	-	-	-
	24	-	-	-
8	24	-	-	-
	24	-	-	-
	24	-	-	-
315	48	-	-	-
	48	-	-	-
	48	-	-	-
1	24	+	-	-
	24	+	-	-
	24	-	-	-
60	48	-	-	-
	48	-	-	-
	48	-	-	-
10	72	+	+	+
	24	-	-	-
	24	-	-	-
	24	-	-	-
18	24	+	-	-
	24	+	+	-
	24	+	-	-
77	48	-	-	-
	48	-	-	-
	48	-	-	-
6	24	+	+	+
	24	+	+	+
	48	+	+	+
2096	24	-	-	-
	24	-	-	-
	24	-	-	-
5	24	+	-	-
	48	+	+	-
	72	-	-	-
	24	-	-	-
2	24	+	+	-
	24	+	+	-
	24	+	+	+
4	48	-	-	-
	48	-	-	-
	48	-	-	-
35	24	-	-	-
	24	-	-	-
	24	-	-	-
48	24	+	+	-
	24	+	+	-
	24	+	-	-
618	24	-	-	-
	24	-	-	-
	24	-	-	-
7	24	+	+	+
	24	+	+	+
	24	+	+	+
46	24	-	-	-
	24	-	-	-
	24	-	-	-
52	48	-	-	-
	48	-	-	-
	48	-	-	-
13	24	+	+	-
	24	+	+	-
	24	+	+	-
53	24	+	-	-
	24	+	+	-
	24	+	+	-
452	24	+	+	-
	24	+	+	-
	24	+	+	-
792	24	-	-	-
	24	-	-	-
	24	-	-	-
464	48	+	+	+
	72	+	+	+
	24	-	-	-

HEN NO	HRS	[illegible]	[illegible]	[illegible]
267	48	-	-	-
	48	-	-	-
	48	-	-	-
8	48	+	+	+
	48	+	+	-
	48	-	-	-
315	72	-	-	-
	72	-	-	-
	72	-	-	-
1	48	+	-	-
	48	+	+	-
	48	+	+	-
60	72	-	-	-
	72	-	-	-
	72	-	-	-
10	48	-	-	-
	48	-	-	-
	48	-	-	-
18	48	-	-	-
	48	+	+	-
	48	+	-	-
77	72	-	-	-
	72	-	-	-
	72	-	-	-
6	48	+	+	+
	72	+	+	+
	72	+	+	+
2096	48	-	-	-
	48	-	-	-
	48	-	-	-
5	24	-	-	-
	24	-	-	-
	48	-	-	-
	48	-	-	-
2	48	+	+	-
	48	+	+	-
	48	+	+	-
4	72	-	-	-
	72	-	-	-
	72	-	-	-
35	48	+	+	-
	48	-	-	-
	48	-	-	-
48	48	+	+	-
	48	+	-	-
	48	+	+	+
618	48	-	-	-
	48	-	-	-
	48	-	-	-
7	48	+	+	+
	48	+	+	+
	48	+	+	+
46	48	-	-	-
	48	-	-	-
	48	-	-	-
52	72	-	-	-
	72	-	-	-
	72	-	-	-
13	48	+	+	-
	48	+	+	-
	48	+	+	-
53	48	+	+	-
	48	+	+	-
	48	+	+	-
452	48	+	+	-
	48	+	+	-
	48	+	+	-
792	48	-	-	-
	48	-	-	-
	48	-	-	-
464	48	-	-	-
	72	+	-	-
	24	-	-	-

HEN NO	HRS	[illegible]	[illegible]	[illegible]
267	72	-	-	-
	72	-	-	-
	72	-	-	-
8	72	+	+	-
	72	-	-	-
	72	-	-	-
1	72	+	+	-
	72	+	+	+
	72	+	+	-
10	72	-	-	-
	72	-	-	-
	72	-	-	-
18	72	-	-	-
	72	+	+	-
	72	+	-	-
2096	72	-	-	-
	72	-	-	-
	72	-	-	-
5	48	-	-	-
	72	-	-	-
	72	-	-	-
	72	-	-	-
2	72	+	+	+
	72	+	+	+
	72	+	+	+
35	72	-	-	-
	72	-	-	-
	72	-	-	-
48	72	+	+	-
	72	+	+	-
	72	+	+	+
618	72	-	-	-
	72	-	-	-
	72	-	-	-
7	72	+	+	+
	72	+	+	+
	72	+	+	+
46	72	-	-	-
	72	-	-	-
	72	-	-	-
13	72	+	+	-
	72	+	+	-
	72	+	-	-
53	72	+	+	+
	72	+	+	+
	72	+	+	+
452	72	+	+	-
	72	+	+	-
	72	+	+	-
792	72	-	-	-
	72	-	-	-
	72	-	-	-
464	24	-	-	-
	48	+	-	-
	48	+	-	-

hens were cystic, exhibiting cysts of varying sizes, and the color was from normal yellow to grayish green. Hen No. 5 showed the least pathological condition of the ovaries. Many ova here were quite normal, and exhibited the usual high-colored picture so characteristic of a healthy ovary. Material from hens Nos. 1, 5, 6, 792, 464, 13 and 452 (previously examined) yielded cultures of *Bacterium pullorum*. Hens Nos. 34, 315, 49, 312, 60, 22, 77, 4, 35, 618 and 46, whose sera had never agglutinated, and in whose eggs *Bacterium pullorum* had not been found, were autopsied. All ova were normal except that of 77, which showed grossly congestion. More than 100 agar tubes were streaked from these ovaries and from materials crushed in sterile bouillon and incubated, and all gave negative results for *B. pullorum*. Hen No. 53, a positive reactor, and hen No. 46, a non-reactor, were killed accidentally, so data on ovaries from these hens were not obtained. The pathological findings of the birds that agglutinated correspond well with those previously described, and especially with previous observations by the author in 1910,[1] and also substantiate the work of Jones.[2] All ovaries from these birds exhibited one or more retention cysts and several irregular lobulated cysts, and the color varied from shades of yellow to green.

Specificity of Bacterium Pullorum Agglutinin.

The first recognition of the agglutination reaction as a separate function of immune sera was by Gruber and Durham.[3] From the first these investigators had claimed specificity for the agglutination reaction, and for this reason it was utilized by Widal for the diagnosis of typhoid fever. Even by early workers it was observed that serum of animals immunized against one micro-organism would often agglutinate to a much less marked degree other closely related species. The serum of a typhoid-immune animal may agglutinate the typhoid bacillus in dilutions of 1–1,000 and higher, and *B. coli* in dilutions as high as 1–200. The normal agglutinative power of *B. coli* does not exceed 1–20. Therefore the specificity of the reaction for practical purposes is not destroyed if the proper dilutions are carried out, the degree or amount of agglutinin formation being always far higher for the specific organism causing the formation of the agglutinin than for closely related species.

After carrying out 300 tests with normal sera from birds known to have no infection, we feel justified in stating that in some instances we were able to obtain slight agglutinative reactions in dilutions of 1–25, but in no instance was there ever exhibited the slightest sign of the agglutination of *Bacterium pullorum* when dilutions 1–100 of normal serum from noninfected individuals were used. For this reason, in the work carried out here, the lowest diagnostic dilution was 1–100. If reaction resulted with *Bacterium pullorum* in this dilution it was considered positive, and the individual rated as a reactor.

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[1] Gage, Geo. Edward: "Notes on ovarian infection with *Bacterium pullorum* (Rettger) in the domestic fowl." Journal Medical Research, Vol. XXIV., No. 3; N. S., Vol. XIX., No. 3; June, 1911, pp. 491-496.

[2] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum*." Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485-495.

[3] Gruber and Durham: Münch med. Woch, 1906.

Since *Bacterium pullorum* has been placed in the *B. coli-typhi-dysenteræ* group of bacteria it was considered of interest to determine if *Bacterium pullorum* agglutinative sera were specific for *Bacterium pullorum.* For these tests the best known members of the *B. coli-typhi* group of bacteria were used. The sera from two hens harboring the organism was drawn and diluted with carbolated salt solution 1–20. Test fluids of uniform turbidity were prepared, as previously for *Bacterium pullorum,* of the following organisms: *B. coli communis, B. coli communior, B. icteroides, B. enteritidis, B. paratyphi A., B. paratyphi B., B. typhi abdominalis, B. Fowl cholera, B. cloacæ, B. lactis aerogenes,* and lastly a test fluid of *Bacterium pullorum.* Complete sets of test tubes were made for each, and to each was added the amount of *Bacterium pullorum* agglutinative sera to give the required dilution. The dilutions in all sets were from 1–100 to 1–5,000, the principal dilutions between these ranges were in the following order: 1–100, 1–200, 1–300, 1–400, 1–500, 1–800, 1–1,000, 1–1,200, 1–1,500, 1–1,800, 1–2,000, 1–2,500, 1–3,000, 1–4,000 and 1–5,000.

By observation of Table 10 it can be seen that the *Bacterium pullorum* agglutinative sera caused agglutination only when put in contact with *Bacterium pullorum.* Not the slightest agglutination occurred in any of the tubes containing test fluid other than *Bacterium pullorum.* From this data it would seem that the *Bacterium pullorum* agglutinin is highly specific, and therefore is of great diagnostic value in all work in which the organism must be determined.

Agglutinins obtained by the Immunization of Rabbits against Bacterium Pullorum.

Rabbits are easily infected with *Bacterium pullorum,* or at least show a marked reaction when injected with pure cultures of this organism; but by a careful procedure of immunization they yield very active agglutinins and also bacteriolytic sera. From 100 tests made in this laboratory it has been found that these agglutinins elaborated in this way are much more stable than those from individuals harboring the organism. Rabbits retained in this laboratory at the present time furnish sera which were active in dilutions up to 1–5,000. Agglutinins in such sera have aided greatly in the diagnosis or differentiation of cultures of *Bacterium pullorum.*

Summary.

From the work carried out at this laboratory during the summer of 1913, the following conclusions appear to be justifiable: —

1. Although the egg test for the determination of *Bacterium pullorum* may yield positive results showing ovarian infection, the elimination is

TABLE 10.

TABLE SHOWING SPECIFICITY OF BACTERIUM PULLORUM AGGLUTININ

HEN No. 1:25	1:100	1:200	1:300	1:400	1:500	1:800	1:1000	1:1200	1:1500	1:1800	1:2000	1:2500	1:3000	1:4000	1:5000
B. COLI COMMUNIS TEST FLUID + B. PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. COLI COMMUNIOR TEST FLUID + B. PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. ICTEROIDES TEST FLUID + B. PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. ENTERITIDIS TEST FLUID + B PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PARATYPHI A TEST FLUID + B. PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PARATYPHI B. TEST FLUID + B. PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. TYPHI ABDOMINALIS TEST FLUID + B PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. FOWL CHOLERA TEST FLUID + B. PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. CLOACAE TEST FLUID + B. PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. LACTIS AEROGENES TEST FLUID + B PULLORUM AGGLUTININ															
A24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PULLORUM TEST FLUID + B. PULLORUM AGGLUTININ															
A24	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
48	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
72	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-

HEN No. 1:25	1:100	1:200	1:300	1:400	1:500	1:800	1:1000	1:1200	1:1500	1:1800	1:2000	1:2500	1:3000	1:4000	1:5000
B. COLI COMMUNIS TEST FLUID + B. PULLORUM AGGLUTININ															
B B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. COLI COMMUNIOR TEST FLUID + B. PULLORUM AGGLUTININ															
B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. ICTEROIDES TEST FLUID + B. PULLORUM AGGLUTININ															
B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. ENTERITIDIS TEST FLUID + B PULLORUM AGGLUTININ															
B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PARATYPHI A TEST FLUID + B. PULLORUM AGGLUTININ															
B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PARATYPHI B. TEST FLUID + B. PULLORUM AGGLUTININ															
B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. TYPHI. ABDOMINALIS TEST FLUID + B. PULLORUM AGGLUTININ															
B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. FOWL CHOLERA TEST FLUID + B. PULLORUM AGGLUTININ															
B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. CLOACAE TEST FLUID + B. PULLORUM AGGLUTININ															
B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. LACTIS AEROGENES TEST FLUID + B. PULLORUM AGGLUTININ															
B24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PULLORUM TEST FLUID + B. PULLORUM AGGLUTININ.															
B24	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
72	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-

irregular and very often covers a long period of time before the organism is detected; therefore it is impractical for rapid diagnosis.

2. Preliminary incubation of the eggs in a bacteriological incubator at 38° to 39° C. prior to testing aids in the determination of the organism.

3. The macroscopic agglutination test as carried out in this laboratory, has proven a good laboratory method for the detection of adult hens harboring, or which have harbored, *Bacterium pullorum.*

4. Our work substantiates that of Jones, in that it is possible to cause a local infection of the ovarian tissue by intravenous injections of pure cultures of *Bacterium pullorum.*

5. The agglutinin is very stable, withstanding temperatures of 60° C. and over for one-half hour. If properly preserved, it will yield results after two weeks. Agglutinins have been found from infected hens which reacted positively in dilutions from 1–100 to 1–5,000.

6. Polyvalent test fluids yield more uniform results than monovalent fluids, although in birds of marked infection monovalent test fluids gave very good results. Test fluids if properly preserved on ice will keep in a very active state for more than two months.

7. Rabbits react to injections with pure cultures of *Bacterium pullorum,* but by careful immunization yield very active agglutinins and also bacteriolytic sera. Agglutinins produced by immunizing rabbits are much more stable than those from hens harboring the organism.

8. A striking pathological condition found in the ovaries of all birds was the exhibition of lobulated and retention cysts which varied greatly in size. From these, it was usually easy to isolate *B. pullorum.*

Acknowledgment. — Thanks are due my sister, Ethel G. Gage, for careful work in connection with calculation and rearrangement of the scientific data from our card-indexing system.

A STUDY OF VARIATION IN APPLES.

J. K. SHAW.

Beginning with the crop of 1908 the apples borne by certain Ben Davis and Baldwin apple trees growing in the college orchard have been measured, both their transverse and longitudinal diameters being taken, and this has been continued up to and including the crop of 1913. This period includes six successive seasons in each of which the Ben Davis trees have borne at least a moderate crop, but the Baldwins have shown some irregularities in bearing. This method has given opportunity for the study of the number of apples borne, the size of the apples and the index of form. Inasmuch as the fruit of each tree has been divided into four lots by bisecting the tree with one plane perpendicular and extending east and west, and with another, horizontal, and about midway of the head of the tree, we have further the opportunity of comparing these factors for what we have called the upper south, lower south, upper north and lower north portions of the trees. Two partial reports of the observations on these trees have been made. For a statement of the method used the reader may be referred to these earlier reports.[1] The present paper reports results to date, and is probably final for this phase of the problem.

The Productiveness of the Trees.

We are not aware of any published data giving the number of apples borne by individual trees for a number of consecutive years. Several have reported the measured quantities produced over a considerable period, and these records have shown marked differences in yield of individual trees. Macoun gives the total yield for several varieties. These figures are taken from his report.[2]

Variety.	Age of Trees (Years).	Years of Bearing.	Number of Trees.	Yields (Gallons).		
				Lowest.	Highest.	Average.
Wealthy,	15	12	14	57.0	203.0	113.5
McMahon,	23	13	8	226.0	889.0	604.4
McIntosh,	21	13	2	367.5	761.0	564.0
Patten,	19	13	5	291.5	597.5	406.1

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[1] Repts. Mass. Expt. Station: 22, Pt. I. (1910), p. 194; 23, Pt. I. (1911), p. 177.

[2] Rept. Central Expt. Farm., 1910-11, p. 118.

The trees on which our observations have been made are eighteen years old, and all are in a healthy, thrifty condition. All have been given the usual orchard care as to pruning and spraying; all were cared for under the cultivation and cover-crop system until August, 1911, when the Baldwin plot was seeded to grass and clover. The trees are similar in size and vigor, though there is some correlation between size and productiveness in the Ben Davis. Tree No. 8 which has produced the most apples is somewhat larger than any of the other trees. The yields of the trees for the period under observation are as follows: —

	1908.	1909.	1910.	1911.	1912.	1913.	Totals.
Tree No. 2, Ben Davis, .	864	251	425	2,453	724	830	5,547
Tree No. 3, Ben Davis, .	567	343	449	1,576	641	966	4,542
Tree No. 5, Ben Davis, .	469	155	360	1,469	354	1,264	4,071
Tree No. 7, Ben Davis, .	423	431	587	1,278	837	1,010	4,566
Tree No. 8, Ben Davis, .	–	686	1,093	2,249	629	1,611	6,268

	1908.	1909.	1910.	1911.	1912.	1913.	Totals.
Tree No. 2, Baldwin, . .	–	321	287	None.	319	None.	927
Tree No. 4, Baldwin, . .	–	621	189	1,541	None.	495	2,846
Tree No. 5, Baldwin, . .	–	319	546	253	830	None.	1,948

The differences in yield between the several trees are not as great as those reported by Macoun, especially in the Ben Davis, which is one of the most regular and abundant bearers. There is little indication of the biennial bearing habit in the Ben Davis, while the Baldwins show it clearly in later years, though they all bore a crop in both 1909 and 1910. No satisfactory reason for these annual fluctuations in crop can be assigned, but it presumably lies largely in weather conditions at the blossoming season, various conditions influencing the number of fruit buds formed during the previous season, and possibly in some degree to insects and disease. The Ben Davis has blossomed freely each year, while the Baldwins have in off years failed to blossom.

Considering for a moment the yields from the different parts of the trees, divided as has been already explained, we find some slight variations of interest. The numbers of apples have been as follows: —

	Upper South.	Lower South.	Upper North.	Lower North.
1908,	518	714	414	676
1909,	552	379	305	287
1910,	707	893	576	869
1911,	2,082	2,111	2,310	2,522
1912,	791	501	677	380
1913,	1,550	1,432	1,393	1,306
Totals,	6,200	6,030	5,675	6,040

These figures are for the Ben Davis trees only, as the Baldwins have been so irregular in bearing as to seriously interfere with any significance that the figures might otherwise have. The upper south quarters of the trees have borne the greatest number of apples, and the annual fluctuations have been least. However, the difference is not great enough to have much significance. So far as it goes it is in accordance with the reasonable supposition that that part of the tree most exposed to the warmth and light of the sun sets the largest number of fruits. As will be shown later the upper south part of the trees have yielded larger apples as well as a few more, so that the yield in barrels should be sensibly greater. If this is true of the parts of the tree, may it not indicate that a southern slope will yield more than a northern one? Probably such an assumption would be hardly justified, especially as the increased size may not hold generally. Also there have doubtless been small variations in the division of the trees from year to year, but these would tend to offset each other when the whole period is considered. Warren,[1] found in Wayne County, N. Y., the highest yields on easterly slopes, while Martin, found in Ontario County that the largest yields were from orchards on level sites followed by those on north, east and west slopes in the order given.[2]

SIZE.

The measurements of the greatest cross diameter seem to reveal significant differences in the size of the apples in both individual trees and different parts of the tree. Of the several Ben Davis trees No. 7 has borne the largest apples, 72.92 millimeters, and No. 3 the smallest, 69.99 millimeters; and there has been a fair degree of consistency in the sizes from year to year, No. 7 not having fallen below third place in any one year, and No. 3 having risen above fourth place only once. The other three trees have shown greater fluctuation from year to year, all having occupied both first and last places in the course of the six years of observation, and the differences in averages are not large. The few figures available for the Baldwins are greater and are consistent from year to year. Tree

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[1] Cornell Bull. 226, p. 326.

[2] Cornell Bull. 307, p. 107.

No. 2 has borne the largest apples and tree No. 4 the smallest, with tree No. 5 intermediate each year. The apples on tree No. 4 were much smaller in 1913 than ever before, due possibly to the previous seeding down to grass and clover.

It seems fair to conclude that individual trees may show a fairly constant tendency from year to year to produce apples larger or smaller than the general average of the orchard.

The extreme difference in average size between the individual trees amounts to a trifle less than 3 millimeters, while between the different parts of the trees it is 2.38 millimeters; but from year to year the differences are more consistent. The apples from the upper south part of the trees have been the largest every year. Those from the upper north part have been second every year except 1911, while the lower north apples have been smallest in four years out of six. This would seem to warrant the conclusion that for the variety the better the exposure of the trees to the sun the larger the growth that may be secured.

The figures for the Baldwins are too fragmentary to be of much value, but so far as they go, while not quite as consistent as those of the Ben Davis, they show the same general tendency. In 1909 the different parts were in the same order as the average of the Ben Davis, while in 1912 the upper north led, followed by the upper south, lower north and lower south.

Considering the average size of the total apples from the Ben Davis trees in the several years we note that they were largest in 1910 and smallest in 1911, the difference between the extremes being 4.04 millimeters. The small size in 1911 is undoubtedly due to the heavy crop borne, but it is significant that this is the only year in which the trees have borne enough to affect the size. There is no relation between size of apples and the number borne until the crop reaches what may be fairly termed a full crop. Probably there is more danger of breaking down the tree than of any serious deficiency in size, provided the trees are well cared for. In 1909 the apples average 90 millimeters in diameter, nearly as small as in 1911. The probable explanation of this is the low temperature prevailing, the March–October mean being the lowest of any of the six years under consideration. There are some further indications of a relationship between the warmth of the season and the size of the apples, but all the fluctuations in size cannot be thus accounted for. We have been unable to trace any relationship whatever between precipitation and size. One possible influence of fertilization is in the case of the crop of 1910, the large size of which may be due to a previous application of lime.

While there is evidence that there has been some relation between mean summer temperature and size it does not appear that the slight variations that have occurred have exercised a controlling influence on the size of the apples. In earlier work along this line a greater effect of temperature was observed, but mostly from stations further north, where seasonal fluctuations of temperature are greater.

A study of the variability in size of the apples from the different trees shows small differences that apparently have some meaning. Those from tree No. 7 are quite consistently the most variable of any, and these have been the largest; there seems to be a possible relationship between size and variability, — the larger the apples the more variable.

As between the apples from different parts of the tree, this relationship does not hold. The apples from the upper south parts of the trees are largest and least variable, and probably the slight differences in variability that occur are simply chance fluctuations.

TABLE 1.—*Size of Apples.*

Ben Davis.

INDIVIDUAL TREES.

Tree No. 2.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	71.02±.14	6.16±.10	8.67±.14
1909,	70.89±.22	5.40±.16	7.62±.18
1910,	73.15±.19	5.69±.13	7.78±.15
1911,	69.15±.07	5.15±.05	7.45±.07
1912,	71.01±.18	6.68±.12	9.41±.17
1913,	75.63±.16	5.43±.09	7.18±.12
Average,	71.81	5.75	8.02
Tree No. 3.			
1908,	68.80±.15	5.31±.11	7.72±.16
1909,	68.48±.19	5.24±.13	7.65±.22
1910,	72.27±.19	6.01±.13	8.32±.22
1911,	69.14±.07	4.11±.05	5.94±.07
1912,	71.71±.15	5.60±.11	7.81±.15
1913,	69.54±.09	4.90±.08	7.04±.06
Average,	69.99	5.20	7.41
Tree No. 5.			
1908,	68.35±.13	5.55±.08	8.12±.13
1909,	68.32±.27	4.96±.18	7.26±.33
1910,	75.53±.21	5.88±.15	8.00±.22
1911,	70.16±.09	5.29±.07	7.55±.09
1912,	74.01±.25	7.08±.18	9.57±.24
1913,	71.69±.13	4.85±.07	6.76±.09
Average,	71.34	5.70	8.02

TABLE 1. — *Size of Apples* — Continued.

Tree No. 7.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	72.80±.18	6.45±.13	8.86±.17
1909,	70.37±.17	5.12±.12	7.28±.19
1910,	75.12±.19	6.85±.14	9.12±.21
1911,	72.69±.11	6.11±.08	8.41±.11
1912,	72.57±.15	6.33±.10	8.72±.14
1913,	73.97±.12	5.69±.09	7.70±.12
Average,	72.92	6.09	8.35

Tree No. 8.

1909,	70.45±.13	4.93±.09	7.00±.13
1910,	72.57±.09	6.16±.06	8.52±.10
1911,	67.12±.08	5.71±.06	8.50±.09
1912,	73.39±.16	5.79±.11	7.90±.15
1913,	71.93±.09	5.48±.09	7.62±.13
Average,	71.69	5.60	7.82

PARTS OF THE TREES.

Upper South.

1908,	70.93±.18	6.40±.13	9.02±.19
1909,	70.96±.14	4.77±.10	6.72±.14
1910,	74.53±.12	4.67±.08	6.27±.11
1911,	70.79±.08	5.66±.06	8.00±.08
1912,	74.34±.13	5.41±.09	7.27±.12
1913,	73.08±.10	5.40±.07	7.39±.09
Average,	72.44	5.38	7.45

Lower South.

1908,	69.24±.14	5.68±.10	8.20±.14
1909,	69.77±.18	5.06±.12	7.24±.18
1910,	72.87±.14	6.33±.10	8.68±.14
1911,	69.86±.08	5.46±.06	7.81±.11
1912,	70.76±.22	7.28±.16	10.29±.22
1913,	71.45±.09	5.27±.07	7.38±.09
Average,	70.66	5.86	8.27

TABLE 1. — *Size of Apples* — Continued.

Upper North.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	71.27±.20	6.14±.15	8.47±.19
1909,	70.86±.20	5.27±.13	7.44±.19
1910,	73.94±.21	6.51±.14	8.80±.19
1911,	69.09±.08	5.65±.06	8.17±.08
1912,	72.37±.15	6.02±.11	8.31±.15
1913,	72.84±.10	5.41±.05	7.43±.09
Average,	71.73	5.83	8.10
Lower North.			
1908,	69.79±.12	4.96±.08	7.11±.12
1909,	69.40±	5.04±	7.26±
1910,	72.32±.14	6.06±.10	8.38±.14
1911,	67.57±.07	5.55±.05	8.21±.08
1912,	70.84±.21	5.93±.15	8.37±.21
1913,	70.43±.09	5.07±.09	7.19±.08
Average,	70.06	5.43	7.75
TOTAL APPLES.			
1908,	70.23±.08	5.95±.06	8.47±.08
1909,	70.00±.08	5.11±.06	7.30±.08
1910,	73.27±.08	6.28±.06	8.57±.08
1911,	69.23±.04	5.70±.03	8.24±.04
1912,	72.42±.08	6.31±.05	8.71±.07
1913,	73.19±.05	5.44±.03	7.44±.05
Baldwins.			
INDIVIDUAL TREES.			
Tree No. 2.			
1909,	78.62±.21	5.59±.15	7.11±.23
1910,	80.22±.23	5.41±.16	6.74±.27
1912,	79.20±.23	6.05±.16	7.64±.20

TABLE 1. — *Size of Apples* — Concluded.

Tree No. 4.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	74.39±.14	5.01±.10	6.73±.15
1910,	76.90±.27	5.57±.19	7.24±.30
1911,	71.78±.08	4.58±.06	6.38±.06
1913,	66.91±.20	6.52±.15	9.74±.22
Tree No. 5.			
1909,	77.66±.21	5.66±.15	7.29±.22
1910,	77.71±.15	5.20±.11	6.69±.15
1911,	78.05±.26	6.07±.18	7.78±.23
1912,	74.16±.12	5.19±.08	7.00±.11
PARTS OF THE TREES.			
Upper South.			
1909,	76.91±.18	5.61±.12	7.29±.16
1912,	77.50±.22	5.47±.16	7.06±.20
Lower South.			
1909,	76.31±.23	5.83±.16	7.64±.21
1912,	73.02±.23	6.11±.17	8.36±.23
Upper North.			
1909,	76.34±.20	5.47±.14	7.19±.19
1912,	77.96±.21	5.41±.15	6.94±.19
Lower North.			
1909,	74.58±.26	5.14±.18	6.89±.25
1912,	74.86±.22	5.58±.16	7.45±.21
TOTAL APPLES.			
1909,	76.29±.11	5.68±.08	7.45±.10
1910,	77.99±.11	5.55±.08	7.12±.10

FORM.

The main purpose of this work has been the study of the variation in form of the apples and the causes thereof. The continuation of our observation has resulted in the accumulation of data that confirm earlier conclusions[1] and afford basis for some further deductions concerning the problem.

Ben Davis tree No. 7 which has borne the largest apples has also borne the most flattened of any, while the most elongated have been from tree No. 8 closely followed by tree No. 2. The mean indexes of form from year to year have also been fairly consistent, No. 7 ranking first four times, second once and fourth once during the six years. The other trees have been more variable, but trees Nos. 2 and 8 have shown a tendency toward elongation. As with size the differences in form are more constant in the different parts of the trees than with the different trees. The upper south apples have been the most flattened every year, but those of trees Nos. 1 and 3 from the lower north portions have been the most elongated four years out of six. The other two portions of the trees have been more variable, but the lower souths have been slightly the more flattened. As regards the standard deviation and the coefficient of variability, they do not seem to have any significance whatever; such small differences as occur are probably wholly chance fluctuations.

Turning now to the discussion of the difference in form from year to year and its relation to air temperature, which has been the main object of inquiry, we find that the paralellism between the variation and the temperature for a period following blossoming previously observed has been maintained in succeeding years. This relationship is shown in Fig. 1, which shows the fluctuations in mean daily temperature for twenty-five days following full bloom. This shows that a low temperature following blossoming is always followed by a low coefficient of form, *i.e.*, relatively elongated apple. The past season of 1913 has been the coolest of any for nearly the whole period of twenty-five days, and the apples have been the most elongated, while in 1908, 1911 and 1912, in which this period was relatively warm, the coefficient of form is much larger, *i.e.*, the apples are more flattened. In the other years both the temperatures and coefficients of form have been intermediate.

The curves of temperature, not only for the period shown in the diagram but for the entire growing season as well, have been carefully scrutinized to ascertain the critical period which determines the form of the apple. Consideration has also been given to other factors of climate, such as rainfall, humidity and sunshine, — whether they may have an effect. As a result of this inquiry there appears no evidence that factors other than that of temperature for a part or all of the twenty-five-day period have any influence. Within this period the temperature from the sixth to

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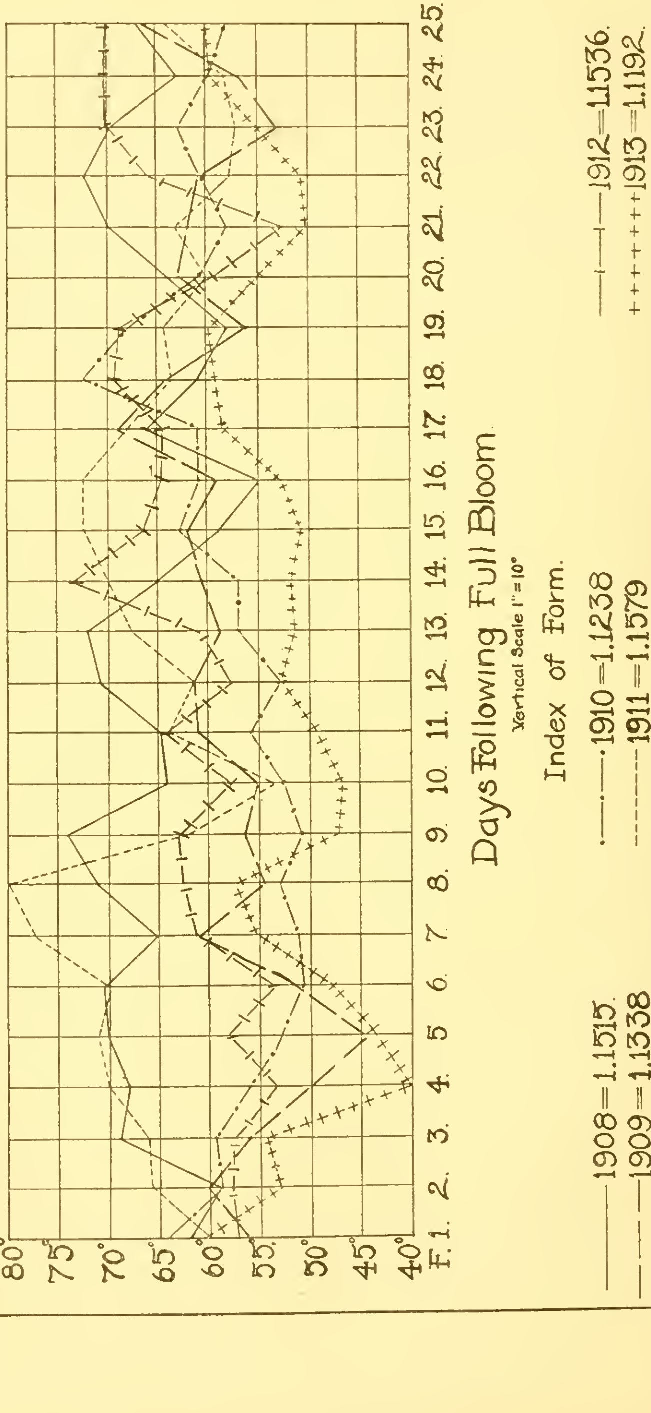
[1] Mass. Expt. Station Rept.: 23, Pt. I. (1911), p. 199.

Figure 1. Fluctuations of daily mean temperatures for periods of 25 days following full bloom of the Ben Davis also indexes of form for the corresponding years.



sixteenth day seems to fit the observed fluctuations in form better than that for any other period. The relationship of the temperature for this period and the coefficient of form are as follows, the arrangement being in the order of the increase of temperature: —

YEAR.	Date of Full Bloom.	Temperature, Sixth to Sixteenth Day.	Coefficient of Form.
1913,	May 7,	51.24	1.1192
1910,	May 7,	54.44	1.1238
1909,	May 19,	58.19	1.1338
1912,	May 11,	62.10	1.1536
1908,	May 19,	67.63	1.1515
1911,	May 15,	67.76	1.1579

An inspection of these figures shows the general relationship, but there are some irregularities, especially in 1912 and 1908. In the latter year this period was slightly over 5° warmer than in 1912, yet the apples were more elongated. Tree No. 8 was not measured in 1908, but its apples have only once been more flattened than the average and then only slightly so. The difference between extremes of temperature for this period is 16.52° (67.76°–51.24°), and in the coefficient of form, .0387 (1.1579–1.1192). This gives an average difference of .0022 for each degree of temperature. If we calculate the relationship of the increase of the coefficient of form with that of temperature from year to year we get the following: —

YEAR.	Increase of Temperature.	INCREASE OF COEFFICIENT OF FORM.	
		Theoretical.	Actual.
1913,	0	0	0
1910,	3.20	.0070	.0046
1909,	6.95	.0151	.0146
1912,	10.86	.0238	.0344
1908,	15.39	.0339	.0328
1911,	16.52	.0363	.0387

Looked at from this viewpoint the only very serious difference between the actual and theoretical increases of the coefficient of form with the rise of temperature is in 1912, when it is 1.1536, whereas it should be, in order to be in harmony with other years, 1.1430. We have endeavored to account for this irregularity, but without success. Presumably some unknown factor operated to disturb the fairly close relationship observed in other years. Probably it will be necessary to attack the problem from another angle in order to understand what this may be.

TABLE 2. — *Form of Apples.*

Ben Davis.

INDIVIDUAL TREES.

Tree No. 2.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1422±.0014	.0576±.0009	3.04±.08
1909,	1.1248±.0024	.0553±.0017	4.91±.15
1910,	1.1159±.0016	.0516±.0012	4.62±.12
1911,	1.1526±.0006	.0458±.0004	3.97±.04
1912,	1.1510±.0016	.0510±.0009	4.43±.09
1913,	1.1282±.0014	.0584±.0010	5.18±.09
Average,	1.1358	.0533	

Tree No. 3.

1908,	1.1399±.0016	.0543±.0011	4.73±.09
1909,	1.1297±.0020	.0553±.0014	4.89±.19
1910,	1.1322±.0015	.0488±.0011	4.31±.11
1911,	1.1662±.0008	.0456±.0005	3.91±.05
1912,	1.1508±.0016	.0586±.0011	5.09±.09
1913,	1.1282±.0012	.0547±.0008	4.85±.07
Average,	1.1412	.0529	

Tree No. 5.

1908,	1.1666±.0019	.0626±.0013	3.76±.08
1909,	1.1295±.0028	.0519±.0019	4.59±.19
1910,	1.1151±.0018	.0512±.0013	4.59±.12
1911,	1.1559±.0008	.0453±.0006	3.92±.05
1912,	1.1571±.0018	.0549±.0014	4.75±.12
1913,	1.1201±.0009	.0492±.0007	4.39±.07
Average,	1.1418	.0526	

Tree No. 7.

1908,	1.1716±.0019	.0578±.0013	3.37±.07
1909,	1.1486±.0017	.0511±.0012	4.45±.11
1910,	1.1333±.0014	.0516±.0010	4.55±.09
1911,	1.1716±.0010	.0528±.0007	4.51±.06
1912,	1.1563±.0012	.0483±.0008	4.17±.07
1913,	1.1170±.0012	.0549±.0008	4.91±.07
Average,	1.1497	.0527	

TABLE 2. — *Form of Apples* — Continued.

Tree No. 8.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1310±.0013	.0494±.0010	4.37±.09
1910,	1.1211±.0007	.0481±.0005	4.29±.05
1911,	1.1558±.0006	.0455±.0005	3.93±.04
1912,	1.1540±.0013	.0491±.0009	4.14±.08
1913,	1.1099±.0006	.0473±.0008	3.94±.07
Average,	1.1342		

PARTS OF TREES.

Upper South.

1908,	1.1643±.0017	.0593±.0012	3.61±.07
1909,	1.1390±.0015	.0520±.0011	4.57±.10
1910,	1.1299±.0013	.0500±.0009	4.43±.09
1911,	1.1610±.0004	.0486±.0005	4.19±.04
1912,	1.1557±.0012	.0505±.0009	4.37±.07
1913,	1.1283±.0009	.0513±.0006	4.55±.06
Average,	1.1464	.0523	

Lower South.

1908,	1.1512±.0015	.0619±.0011	4.19±.07
1909,	1.1302±.0018	.0516±.0012	4.57±.12
1910,	1.1249±.0011	.0489±.0009	4.35±.08
1911,	1.1614±.0009	.0468±.0005	4.03±.04
1912,	1.1609±.0014	.0461±.0010	3.97±.08
1913,	1.1156±.0007	.0416±.0005	3.73±.05
Average,	1.1407	.0496	

Upper North.

1908,	1.1553±.0020	.0607±.0014	3.91±.08
1909,	1.1333±.0020	.0509±.0014	4.40±.14
1910,	1.1216±.0016	.0544±.0010	4.85±.10
1911,	1.1598±.0004	.0470±.0005	4.05±.04
1912,	1.1430±.0013	.0487±.0009	4.26±.08
1913,	1.1241±.0010	.0527±.0007	4.34±.06
Average,	1.1395	.0527	

TABLE 2. — *Form of Apples* — Continued.

Lower North.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1406±.0016	.0644±.0011	4.58±.07
1909,	1.1338±.0021	.0529±.0015	4.67±.14
1910,	1.1171±.0012	.0505±.0008	4.52±.08
1911,	1.1511±.0006	.0454±.0004	3.95±.04
1912,	1.1537±.0018	.0505±.0012	4.37±.11
1913,	1.1065±.0009	.0529±.0007	4.78±.06
Average,	1.1338	.0528	

TOTAL APPLES.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1907,	1.1656±.0023	.0581±.0017	4.98±.14
1908,	1.1515±.0008	.0589±.0006	5.29±.05
1909,	1.1338±.0009	.0527±.0006	4.65±.06
1910,	1.1238±.0007	.0504±.0004	4.48±.04
1911,	1.1579±.0003	.0472±.0002	4.07±.02
1912,	1.1536±.0006	.0499±.0004	4.33±.04
1913,	1.1192±.0005	.0518±.0003	4.63±.08

Baldwins.

INDIVIDUAL TREES.

Tree No. 2.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1615±.0022	.0579±.0015	4.98±.13
1910,	1.1745±.0021	.0536±.0015	4.56±.15
1912,	1.2006±.0023	.0605±.0016	5.04±.14

Tree No. 4.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1848±.0014	.0523±.0010	5.41±.10
1910,	1.1834±.0027	.0553±.0019	4.67±.17
1911,	1.2342±.0008	.0469±.0006	3.80±.05
1913,	1.1962±.0024	.0774±.0017	6.47±.15

TABLE 2. — *Form of Apples* — Concluded.

Tree No. 5.

[Millimeters.[

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1790±.0024	.0644±.0017	5.46±.16
1910,	1.1878±.0018	.0622±.0013	5.23±.12
1911,	1.2307±.0027	.0637±.0019	5.18±.16
1912,	1.2248±.0011	.0485±.0008	3.96±.07
TOTAL APPLES.			
1909,	1.1774±.11	.0583±.08	4.96±.07
1910,	1.1844±.12	.0567±.08	4.79±.07
1912,	1.2180±.10	.0502±.07	4.27±.06

SUMMARY.

1. These Ben Davis trees have borne much more heavily than the Baldwins and have shown hardly any tendency to biennial bearing.

2. Among five Ben Davis trees the most prolific tree has exceeded the least prolific by more than 60 per cent. in number of apples in the total for six crops. The Baldwins have shown even greater differences.

3. The upper south quarters of the Ben Davis trees have borne a few more apples than any of the other three quarters. This may be significant or only a chance difference.

4. Some Ben Davis trees showed a fairly constant tendency to produce apples larger or smaller than the average; others fluctuated from season to season.

5. Ben Davis apples from the upper south quarters of the trees run constantly larger than those from the other parts; those from the opposite quarters were generally smallest.

6. Only once in the case of a very heavy crop has the number of apples been large enough to affect the size.

7. There are some slight indications of a relationship between size and the average summer temperature, but the fluctuations in temperature have probably not been large enough to overcome other influences affecting size.

8. Some trees showed slight individuality in the amount of variability, and this may be correlated with size, — the larger the apples the more variable. This is not true as between the different parts of the trees.

9. As with size, some trees showed quite constant individuality in form of fruit, while others were variable. There seems to be no strong evidence that individuality in size and form are to be found in the same tree.

10. The apples from the upper south parts of the trees, which were largest, were also constantly the most flattened.

11. There is a pretty constant relationship between the form of the apple and the temperature for a period following bloom; the cooler this period the more elongated the apple.

12. An effort to delimit this period more closely indicates that the period from the sixth to the sixteenth days following full bloom fits the observed fluctuation in form more closely than any other.

REPORTS ON EXPERIMENTAL WORK IN CONNECTION WITH CRANBERRIES.

H. J. FRANKLIN AND F. W. MORSE.

REPORT OF CRANBERRY SUBSTATION FOR 1913.[1]

The year's experiments and observations may be discussed under the ten following heads: weather observations, frost protection, fungous diseases, varieties, blossom pollination, fertilizers, insects, weeds, resanding and miscellaneous.

1. WEATHER OBSERVATIONS.

Blanks have been prepared for recording on a single sheet all the more important phenomena observed in connection with every frosty night during the cranberry growing season. On these blanks space has been left for recording the minimum temperatures at 15 stations (bogs) besides that at the station bog. It is also planned to note in this record the amount of injury (estimated) on the Cape and in New Jersey caused by each severe frost. It is hoped that the mass of data condensed in such records will make it possible to better understand the Cape frost weather conditions and to make more satisfactory frost predictions as a result. Only a few of the temperature observing stations planned for have, as yet, been established, but it is hoped that another season will see all the thermometers properly placed for taking a fairly representative lot of minimum temperature observations for the entire Cape. The barometric changes and their influence on frost conditions, both as indicated by the weather map and as shown by the action of the barometer itself, have been carefully studied, with some interesting results. The high barometric waves appear, as a rule, to be most dangerous when they extend both far to the North and far to the South, without any low wave on the Atlantic seaboard to the south of us. One of the great uncertainties about the barometric action, as far as the weather map is concerned, seems to be caused by the occasional more rapid deepening of a low wave in or around the lower St. Lawrence valley, than is offset by the advance of the high wave, the general result being a fall of the barometer in an important section where a rise would, as a rule, be expected. This fall of the barometer in the northeast often causes the wind to keep up all night when other conditions would lead a forecaster to expect almost a dead calm. There seems to be no way of figuring on this action of the barometric waves, except by more extensive observations of conditions in the eastern Provinces of Canada than are at present carried out by the Weather Bureau. The officials of the Weather Bureau are planning to take special afternoon barometric observations in that section, in order to forecast our frost conditions more accurately.

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[1] By H. J. Franklin.

Another puzzling factor is the occasional occurrence of cloudiness on mornings when, from the general weather conditions, no cloudiness would naturally be expected. It seems quite possible that we may not be able to fully understand the causes of such cloudiness without a study of the conditions of the upper atmosphere. This is of course a very important matter, for the presence of clouds always makes a difference of several degrees in the temperature of a cold night.

The readings of the maximum and minimum shelter and bog thermometers, and the amounts of precipitation, were telegraphed to the office of the United States Weather Bureau at Boston, every morning after May 4, during the spring and fall periods of frost danger. Triple register (for sunshine, wind direction and wind velocity), thermograph, and barograph records were taken in the usual way throughout the season, from early May until the last of October. As the hydrograph did not work satisfactorily no records were made with that instrument.

There seems to have been this year a general increase in confidence, on the part of the growers, in the forecasts sent out from the Boston office of the Weather Bureau. This increased confidence is probably fully justified, for the forecasts seem to have been much more accurate during the past season than formerly.

2. FROST PROTECTION.

Careful consideration has been given to the different possible methods of frost protection where water is not available for use in the usual way.

It was suggested in last year's report that it might be possible to use the Skinner system, or some other sprinkling arrangement, with an engine and pump only large enough to pump water for one section at a time, the idea being to draw the frost out of the vines by one or two applications of cold water in the morning, before they were thawed out by the heat of the sun. The practicability of this method was tried out on a small scale last May with a spraying outfit, and the results seemed to be far from satisfactory, for the sprayed areas afterward appeared to show distinctly more injury than did the surrounding unsprayed portions of the bog. As the whole matter now stands, therefore, it does not seem at all probable that the Skinner system can very well ever be made practical use of for frost protection. Its undesirability from the standpoints of expense and nozzle clogging were discussed in last year's report. All other sprinkling systems at present on the market are even more expensive, and will probably, on this account, never be practically available for this purpose.

As indicated in last year's report, the expense connected with the use of orchard heaters is prohibitive, to say nothing of the danger from fire, and of the injury to the vines which would unavoidably be done by the spilling of oil.

There are many other possible methods of frost protection for cranberry bogs which have not yet been tried. It may be possible to cause the frost to be drawn out slowly from the vines after a frost by screening the bog from the sun during the first two or three hours of the morning, perhaps by a curtain of smoke. This method is suggested by the well-known fact that the greater part of the injury, caused by freezing in both plant and animal tissues, is usually due more to the sudden withdrawal of the frost in the process of thawing than to the formation of the frost in them.

The possibility of protecting a bog from frost by covering it over with cloth is of course generally recognized. Though this would be an expensive protection, it has the probable advantage of being entirely effective. It is, however, probably unwise to attempt any special frost protection on dry bogs because of the peculiar conditions and difficulties otherwise associated with such bogs. The only kind of bogs, the general conditions of which probably warrant special protection, are those which are winter-flowed but cannot be reflowed to any extent.

As a rule, the managers and owners of most of the Cape bogs, which have poor frost protection, seem to have overlooked the method of protection, which, though not perfect, is, nevertheless, many times very effective, and which can be applied with a relatively small cost, namely, that of keeping the bog well sanded. It has been shown by the experiments carried out by Prof. H. J. Cox for the United States Weather Bureau and by the Wisconsin Station that there is a protection against several degrees of frost to be had by this use of sand. Many of the Cape growers have come to realize this from general experience, and striking examples of the efficiency of this protection are not infrequently seen. It seems certain that a very considerable percentage of the Cape cranberry losses from frost, incurred where water protection is not available, could be saved by a more general understanding and application of this principle of re-sanding for protection.

3. FUNGOUS DISEASES.

The arrangement by which this work has heretofore been carried on in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture has been continued this year. Dr. Shear has had general supervision of the spraying experiments as heretofore and has conducted the laboratory investigations. A considerable number of spraying tests were carried on by the growers, especially in Wareham and in and about Harwich, the results of some of which have not as yet been received. The five plots, each four rods square, which were sprayed in 1911 and 1912 as indicated in previous reports, were all sprayed again this season with Bordeaux mixture used in the same way as last year (3 pounds of lime, 4 pounds of copper sulphate and 2 pounds of resin fish oil soap to 50 gallons of water), but a greater number of times, plots A and C (Lake Howe plots) being sprayed with the Bordeaux on June 5, June 17, June 28 and July 19, and with neutral copper acetate (1 pound to 50 gallons of water) on August 7. Plot B (the McFarlin plot) was sprayed with Bordeaux mixture on June 6, June 18 and July 21. Plots D and E (the Early Black plots) were sprayed with Bordeaux mixture on June 6, June 18, July 11 and July 22. The crop was gathered from these plots and their checks on dates and in amounts as follows, the quantities being given in bushels: —

TABLE 1.

PLOT.	Area (Square Rods).	Date when picked.	Variety.	Quantity of Fruit (Bushels).	Quantity per Square Rod (Bushels).	Average of Double Checks per Square Rod.	Per Cent. of Decrease on Sprayed Plots.
A, ...	16	Sept. 24	Howe.	8 1/6	.5100	-	74
A (check 1), .	4	Sept. 25	Howe.	4 1/15	1.0170	1.942	-
A (check 2), .	9	Sept. 25	Howe.	25 4/5	2.8660		
B, ...	14 1/8	Sept. 25	McFarlin.	13 1/4	.9380	-	49
B (check), . .	13 2/3	Sept. 25	McFarlin.	25	1.8300	-	-
C, ...	16	Sept. 24	Howe.	9	.5625	-	53
C (check 1), .	4	Sept. 24	Howe.	5	1.2500	1.198	-
C (check 2), .	8	Sept. 24	Howe.	9 1/6	1.1460		
D, ...	16	Sept. 17	Early Black.	19 2/3	1.2300	-	45
D (check 1), .	3	Sept. 17	Early Black.	6 2/5	2.1330	2.240	-
D (check 2), .	9	Sept. 24	Early Black.	21 1/9	2.3460		
E, ...	16	Sept. 3	Early Black.	21 1/2	1.3440	-	26+
E (check 1), .	8	Sept. 3	Early Black.	15	1.8750	1.830	-
E (check 2), .	4	Sept. 3	Early Black.	6 1/2	1.6250		
E (check 3), .	4	Sept. 3	Early Black.	8	2.0000		

It will be seen from this table that there was a general very marked falling off in the fruit produced by these sprayed plots as compared with the surrounding untreated portions of the bog. Where two checks were laid out for the same plot (as noted in the table), they were in every case located on different sides of the sprayed area. The berries were all picked with scoops. The spraying was done with a 30-gallon wheeled-barrel outfit, as heretofore, but the mechanical injury done in the process of spraying was not very great, as a long hose was used, and the outfit was in no case taken onto either the sprayed areas or their checks. The general result of this spraying is interesting in the light of the observations made in connection with the Early Black and McFarlin plots in the late fall of 1912. At that time it was noticed that these plots seemed to have foliage of a much lighter and more sickly appearance than was shown by the vines of their checks. As noted in last year's report, this contrast was very marked and led to the suspicion that, on account of the evidently unthrifty condition of the sprayed areas, they would not, in the season of 1913, produce as good a crop as their checks. The situation suggests that there was not sufficient available plant food present for the sprayed vines, while they were producing the 1912 crop, to maintain a strong vine condition and at the same time develop the extra amount of fruit which the reduction of fungous diseases, caused by the spraying, had made possible. Whether this was the real cause for the decreased fruiting of these plots, or whether the spraying had done the bog injury in some unknown way, it is, as yet, impossible to state with certainty. It should be noted in this connection that in the fall of 1913 the vines of all these plots showed an even more marked unthrifty and sickly appearance in comparison with their checks than they did in the fall of 1912, though they had not, as shown in the table, produced nearly as large crops as the checks. The Howe plots (A and C), which did not show in 1912 any marked effect on the vines, in the fall of 1913 were so red all over (except the fertilized middle portion of plot A) as to give the impression, to one viewing the bog from a distance, that the fireworm had been working severely on them. This would seem to indicate that the spraying had in some way caused a cumulative injury.

On June 28, the middle half of plot A (one of the Howe plots) was fertilized, a quarter of the plot on each side being left without fertilizer, the fertilizer being used on the middle portion at the following rate: nitrate of soda, 200 pounds per acre; acid phosphate, 400 pounds per acre; high-grade sulphate of potash, 200 pounds per acre. This fertilized middle half (8 square rods) of the plot produced 5 1/12 bushels of berries, while the unfertilized side strips (the area of each being 4 square rods) produced, respectively, 1 1/12 bushels and 2 bushels. It will be seen from these figures that there was a very marked increase of fruit on the middle portion, due to the application of the fertilizer. This is particularly interesting because, at the time when the fertilizer was applied, the vines were going out of bloom, and there was no rain to speak of, to dissolve the fertilizer and wash it into the soil, for several days after the application. It is the first time in our experience that fertilizers have been known to cause a marked increase in the amount of fruit on a cranberry bog in the first season applied. This is suggestive in several ways. It looks as though vines which have borne a larger crop, due to freedom from fungous disease brought about by spraying, need an extra supply of plant food the following year in order to maintain their vigor and hold their own in fruiting with unsprayed vines. The results of this fertilizing and spraying may perhaps also be taken to indicate that fertilizers will do their best work in driving fruit production only when the vines are comparatively free from fungous disease. They also suggest the possibility that there is a best time for applying fertilizers, in order to get the best fruiting, perhaps at about the blossoming period. A rather marked increase in fruit production, following a first application of fertilizers rich in nitrates, during the blossoming period, on Howe vines, was noted on some other bogs toward the close of the season. There seems to be much yet to be learned along these lines by further experimenting.

An unexpected result of the spraying, noticed on all five of our old fungous plots during the season, was the killing of the wood moss. This moss appears to have been completely killed out on every one of these plots, while, on the general bog surrounding some of them, it is present in considerable abundance and very much alive up to the very edge of the plot.

When the fruit was gathered from these five plots, no marked difference in color between the berries from the sprayed plots and their checks was observed. The size of the berries from the Early Black and McFarlin plots was practically the same as that of the berries from the checks, but the berries from plots A and C (Howe plots) were distinctly smaller than those from their checks, as shown by the following averages of counts of berries in cupful samples (New England Cranberry Sales Company's inspector's cup) from the different plots and their checks, the samples being in each case taken as evenly as possible from the various boxes: —

TABLE 2.

PLOT.	Number of Samples counted.	Average Number of Berries per Sample.	Variety.
A (fertilized middle portion),	8	96	Howe.
A (the unfertilized side portions),	4	97	Howe.
A (check),	8	90	Howe.
B,	8	60	McFarlin.
B (check),	8	61	McFarlin.
C,	8	102	Howe.
C (check),	8	96	Howe.
D,	6	113	Early Black.
D (check 1),	4	110	Early Black.
D (check 2),	6	108	Early Black.
E,	6	109	Early Black.
E (check),	6	109	Early Black.

The keeping qualities of the berries from these five old fungous plots and their checks were tested, with the results shown in the following table: —

TABLE 3.

PLOT.	Date picked.	Test begun.	Test ended.	Quantity tested (Boxes).	Quantity of Sound Fruit after screening (Boxes).	Percentage of Loss.	Variety.
A (fertilized middle portion).	Sept. 24	Oct. 28	Dec. 19	4	3 3/8	15 2/5	Howe.
A (unfertilized side portions).	Sept. 24	Oct. 28	Dec. 19	2	1 2/3	17 2/3	Howe.
A (check), . .	Sept. 24	Oct. 28	Dec. 20	4	3 1/14	23 1/6	Howe.
B, ...	Sept. 25	Oct. 28	Dec. 23	4	3 1/13	23	McFarlin.
B (check), . .	Sept. 25	Oct. 28	Dec. 23	4	3	23	McFarlin.
C, ...	Sept. 24	Oct. 28	Dec. 19	4	3 5/8	10 3/10	Howe.
C (check), . .	Sept. 24	Oct. 28	Dec. 19	4	3 1/7	21 1/3	Howe.
D, ...	Sept. 17	Oct. 28	Dec. 22	3	2 1/11	30 2/5	Early Black.
D (check 1), . .	Sept. 17	Oct. 28	Dec. 20	2	1 1/4	38 1/4	Early Black.
D (check 2), . .	Sept. 24	Oct. 28	Dec. 23	3	1 2/3	44 1/8	Early Black.
E, ...	Sept. 3	Oct. 28	Dec. 17	3	2 1/2	17 2/3	Early Black.
E (check), . .	Sept. 3	Oct. 28	Dec. 17	3	2 1/8	29 2/5	Early Black.

The boxes used in measuring for these tests, as well as for all other keeping tests conducted during the season, measured 19¼ inches by 14½ inches by 8½ inches, and no considerable error was allowed to creep into the measurement of the fruit on account of variation in the dimensions of the boxes. The fractions given in the above table are only approximate, it being considered that absolute accuracy is not of sufficient importance to call for the including of large numbered fractions. In all the season's storage tests the berries were stored without screening or hoppering. When they were picked, the vines were cleaned out from the boxes by hand as carefully as possible, so that there might be uniformity among the boxes in the quantity of vines they contained. When measured for storage (on October 28 and 29), the boxes were carefully shaken and filled level full, and after screening the berries were again thoroughly shaken before they were measured.

Judging from the figures, concerning the berries from plots D and E given in Table 3, it might be thought that these tests showed a superior keeping quality for early picked berries. While it is not, of course, impossible that this factor may have entered into the results of the tests, it should be borne in mind that the two plots in question are located on the bog at a considerable distance from each other, and there is always more or less variation in the berries of the same variety harvested from the different portions of the bog. Supporting this fact is the fact that last year the berries from plot D kept better than did those from plot E, the reverse of the results obtained by our keeping tests this year.

The results of the tests of the keeping qualities of the berries of the McFarlin plot and its check are remarkable in that they appear to indicate absolutely no effect resulting from the spraying, a result never before even nearly approximated in any test of berries, which had been sprayed with Bordeaux mixture, carried out at the station bog. It should be noted in this connection that the McFarlin berries, both sprayed and unsprayed, on the station bog, and apparently also on other bogs in its vicinity, kept unusually well this year, apparently as a natural result of the peculiar weather conditions.

Three new fungous plots were this season started on the station bog. One of these (on Howe vines) was sprayed with lime-sulphur solution, made from Frost's Powdered Lime-Sulphur, on June 7, June 18, June 28, July 21 and August 7. This plot was picked on September 28. Its area is 9 square rods, and it yielded 5⅓ bushels, while a check of 6 rods immediately adjacent yielded 12⅔ bushels. The marked decrease on the sprayed area was probably due to some injury caused by the spray. The berries from this plot and its check were tested for keeping quality, the results being in favor of the check, the percentage of loss among the berries of the plot being 34½, while amongst those of the check it was only 25½. As far as the results obtained from this plot are concerned, therefore, there seems to be nothing to be said in favor of this preparation for use as a cranberry fungicide. It is planned to continue this test another season.

Another of the new plots was sprayed with Bordeaux mixture, prepared in the usual way, on June 7, June 17, June 28 and July 21, and with neutral copper acetate on August 7. The area of this plot is 9 square rods and it yielded 7⅓ bushels, while its check of equal area yielded 12 bushels. In the storage tests the loss among the berries from this plot was approximately 17 per cent., while its check showed a loss of 27⅕ per cent.

One-half of the fertilizer plot which had, previous to 1913, been treated the most heavily with nitrate of soda, was also sprayed during the season, for the first time, for the purpose of learning about the combined results of fertilizing and fungous spraying. The spraying with Bordeaux mixture was done on June 6, June 17, July 11 and July 21, and neutral copper acetate was used on August 7. The whole fertilizer plot (plot 15) was picked on September 16, and the sprayed portion yielded only 3½ bushels, while the unsprayed portion gave approximately 6⅓ bushels. In the keeping tests, begun with these berries on October 28 and ended on December 22, the sprayed berries showed a loss of only 31⅖ per cent., while the unsprayed lost 44⅗ per cent.

It will be seen from the figures here given that there was a marked decrease in the fruit production on both of the two new plots treated with Bordeaux mixture and neutral copper acetate. This is in accord with the results generally obtained in the co-operative spraying tests carried on on other bogs by the growers during the season, at least in those tests in which spraying was done during the blooming period. While it is impossible to say definitely what caused the falling off in the fruiting on the sprayed areas, it seems highly probable that the Bordeaux mixture was in some way injurious when used during the blooming period. This can be determined only by further tests.

The new disease, spoken of as the "blossom end rot" in last year's report, was much in evidence, after picking, among the Howe berries of the station bog again this year, most of the rot among those berries being evidently due to it. During the month of October, samples of Howe berries were collected from 54 different bogs, for the purpose of gaining some knowledge concerning the distribution and severity of this disease on different parts of the Cape, as such knowledge seemed not only desirable from the scientific standpoint but also more or less essential for practical purposes. The bogs from which these samples came were distributed as follows: Chatham, 2; Harwich, 4; Mashpee, 1; Falmouth, 1; Nantucket, 1; Wareham, 16; Carver, 7; Marion, 2; Rochester, 2; Plymouth, 3; Middleborough, 2; Pembroke, 2; Hanson (including Bryantville and South Hanson), 11.

The "blossom end rot" was found to be present in varying amount in all the samples collected, and the examinations (made from December 11 to December 15, inclusive) appeared to produce no certain evidence that there is any very distinct sectional variation in the degree of its prevalence among the different portions of the Cape. The largest percentage of loss found to have been certainly caused by this disease, at the time of examination, in any of these collected samples, was roughly 8½ per cent., and the smallest loss found in any sample was roughly 1⅓ per cent. Much of the rot present, however, which did not show the characteristics of this disease definitely was probably, nevertheless, caused by it.

Experiments with Copper Sulphate in the Flowage.

In June, tests were begun looking for the control of fungous diseases on cranberry bogs by the application of copper sulphate in the flowage. These tests were carried out on the flooding sections of the station bog. The strengths of the copper sulphate tried were 1 part to 50,000 parts of water (1 pound in 6,250 gallons) on sections 23 and 25 and 1 part to 100,000 parts of water (about 1 pound in 12,500 gallons) on section 27. The copper sulphate was first dissolved in pails of water, and the solutions were distributed as evenly as possible in the flowage of these sections by throwing them into the flowage by the cupful. This treatment was applied to these sections on June 3 and again on June 16.

On section 23, each treatment was continued about twenty-three hours, the chemical being applied to the flowage within an hour or two after the section was completely flooded. As the whole bog was flooded at the same time that the flooding sections were flowed for this treatment, the vines were more or less wet for several hours before the copper sulphate was put in the water.

On section 25 the treatment was continued for eleven hours and was applied after twelve and one-half hours of complete flooding without treatment.

On section 27 the duration of the treatment was about eleven hours and as with section 25 followed twelve and one-half hours of complete flooding without treatment.

When the first treatment was applied to these sections the blossom buds were well developed and prominent, and when the second treatment was applied they were approaching near to blooming, there being here and there a blossom already opened. The treatment did not appear to affect the buds on sections 25 and 27 injuriously in any way. Some of those on section 23, however, were spotted slightly, showing that the solution used had probably been fully as strong as was desirable.

The strength of the solution used on section 23 was recommended to me by Dr. Shear, as the result of laboratory experiments which he had conducted. Unfortunately, spanworms worked seriously on section 23 and reduced the crop to such an extent as to destroy the results of the experiment so far as the amount of the fruit might give any evidence concerning the effect of the treatment.

At picking time sections 25 and 27 yielded fruit at approximately the same rate as the untreated flooding sections immediately adjacent, while section 23 showed a marked falling off. These sections were picked on September 2.

The berries from all the flooding sections were tested for keeping quality, the period of storage extending from October 29 to December 17. The treated sections 25 and 27 showed little if any improvement over the untreated sections. The berries from section 23 seemed to keep better than those from the other flooding sections, but the difference was not sufficiently marked to justify the conclusion that the copper sulphate treatment had been decidedly beneficial.

4. VARIETIES.

Investigations looking toward the possible development of more desirable and more prolific varieties were continued, especially prolific vines of the late Howe and Vose's Bell varieties being marked for observation next season. Some interesting and apparently valuable sports of the Late Howe variety were also found and were marked. Unfortunately, the majority of the uprights, marked in previous years on account of their prolificness, did not bear well in 1913, though there were a few exceptions.

Samples of the berries of most of the different varieties grown on the Cape were collected in October. Samples of vines were also collected where it was possible to get them without too much trouble. Later these samples were studied more or less carefully, and the varieties which appeared to be mixtures of two or more distinct varieties were separated in a general way into their component parts. From these collected samples smaller samples, numbering in all 180, were taken and bottled in alcohol and formalin for future study and reference. The following are the varieties which were thus sampled, together with the number and general location of the bogs from which samples of each were taken: —

TABLE 4.

VARIETY.	Number of Bogs from which Samples were taken.	General Location of these Bogs.
Early Black,	1	East Wareham.
Late Howe,	1	East Wareham.
Early Red,	2	Wareham (East and West).
Early Red (?),	1	East Wareham.
Centerville,	2	South Carver and East Wareham.
Perry Red,	1	Marion.
Matthew,	8	East Wareham, Pleasant Lake, Bryantville and South Chatham.
Jersey Berry,	1	West Wareham.
Centennial,	3	Carver.
Champion,	1	Carver.
Mammoth,	2	Bryantville.
Bugle,	5	Santuit, Carver, Bryantville and East Wareham.
Horseneck,	1	Marion.
Berry Berry,	2	Wareham.
Samuel Small's Bugles,	1	Harwich.
McKinley (or Berlin),	1	Chatham.
Cherry Berry,	1	Plymouth.
McFarlin,	5	Carver and East Wareham.
"Howe,"	1	Wareham.
"Howe,"	1	East Wareham.
"Howe,"	1	East Wareham.
Carver Red,	1	Marion.
Unknown Variety,	1	Mashpee.
Vose's Bell (or Pride),	1	Marion.
Shaw's Success,	2	Carver.
Reds,	1	Bryantville.
Smalley's No. 1,	1	East Wareham.
Smalley Berries,	2	South Harwich and East Wareham.
Hocanun,	1	South Hanson.
Aviator,	1	Carver.
North Cape Howe,	1	Wareham.
Leonard Robbins' Berry,	1	Harwich.
Atkins' Seedling,	4	Brewster, Harwich and Plymouth.

Several of the less well known of these varieties, judging from the appearance and condition of the samples when they were examined in January and from the notes obtained when the collection was made, appear to have highly commendable qualities and would probably give a good account of themselves if they were more extensively planted.

5. BLOSSOM POLLINATION.

The plots, from which bees were screened out on the station bog during the blossoming periods of 1911 and 1912, yielded fruit in 1913 at approximately the same rate as the surrounding bog. A new plot was screened off during the 1913 blossoming period with wire netting through which no bee could work its way. There were a few blossoms present when the screen was put in place, but these were all carefully picked off. The crop on this plot was picked on October 8 and amounted to 2¾ quarts, the area of the plot being approximately half a square rod, while the crop produced on any equal area of the surrounding bog was not less than a bushel. It will be noted that this result was in accord with the general results obtained in all similar previous experiments, except that the results with last year's plot were not nearly so striking.

As it was evident at a glance that the margins of the 1913 plot were bearing more berries than its central portion, a margin 9 inches wide was marked off around the plot and picked separately. The total area of this margin was approximately 34 square feet, slightly more than one-fourth of the entire area in the plot, yet it yielded 664 berries, while the whole plot produced only 1,452. A further marked peculiarity noted was that the portion of this margin lying on the upland side of the plot bore much more heavily than did the remainder, the plot being located at the edge of the bog, just across the ditch from the upland.

While these observations seem suggestive, it does not seem that any definite conclusion can be drawn from them.

6. FERTILIZERS.

The station bog plots used in the 1911 and 1912 fertilizer tests were again treated in 1913 with the same kinds and quantities of fertilizer as before. Because of reflowing operations just before the bloom, the fertilizers were applied later than usual, — on July 15. At picking time it was found that the fertilized plots had not, as a rule, produced as many berries as the check plots, the reverse of the result obtained last year. The decrease on the fertilized plots was not very marked, however, except with plots 14 and 15, these being the two plots on which nitrate of soda had been used in the largest quantities. Plot 15 showed a much greater falling off than did 14, and it had received heavier applications of the nitrate than had 14. This result is somewhat surprising in view of the fact that these two plots had by far the heaviest blossom of any portion of the bog. For some reason, however, there was a marked drying up of the blossoms and small berries on these plots, especially on plot 15, not observed to any such extent on other portions of the bog. The conditions were such that, all things considered, this drying up could not very well be laid to dry weather. The reduced fruiting seems to have been due to a detrimental effect of the nitrate, though it is perhaps impossible to say with certainty just what the effect was.

It must be remembered that half of plot 15 was this year sprayed for fungous diseases as well as fertilized, but the unsprayed portion showed a marked falling off in the quantity of fruit as well as the sprayed portion, though the reduction was not so great on the unsprayed part.

All the fertilizer plots were picked with scoops on September 15 and 16. The berries appeared so uniform in color and most other respects that no records were made except those concerning their quantity and size. The average counts of berries in several cup samples taken from each of the plots did not show any considerable differences in size that could apparently possibly be considered to have been caused by the fertilizer.

Storage tests were carried out with berries from all the plots, beginning on October 28 and 29 and ending December 17 to 23, the results of which did not appear to show any marked effect on the keeping quality, attributable to the use of the fertilizers, except with the berries from plot 15. The berries from this plot showed poor keeping quality, due apparently to the excessive use of nitrate of soda. It will be remembered, in this connection, that this plot has received heavier applications of the nitrate than have any of the others.

7. INSECTS.

This year saw a marked decrease in the prevalence of both the flowed-bog fireworm (black head cranberry worm) and the fruit worm. Last year the injury done by both of these insects was abnormally severe as compared with that of most of our recent seasons. This year, however, both insects caused comparatively little trouble, a surprising fact, considering the damage done by them last year. The causes of this year's reduction of these two pests are obscure, but it seems possible that some condition of the weather during some period of the year was responsible for it. If so, the most marked peculiarity noted in these conditions was the very open winter of 1912–13, especially during December and January. Probably the only way in which we can come to any definite conclusion concerning the bearing of weather conditions on the prevalence of these insects is to keep a careful record for a long period of years, and make comparisons of the experiences of one year with those of another.

The season of 1913 has had other peculiarities from the standpoint of cranberry insect troubles, especially in an unusual prevalence of cutworms and of spanworms of several different species. During the season numerous reports came in from cranberry growers, telling of threatening gypsy moth trouble, and the little cranberry snout beetle seemed to be more troublesome than usual.

On August 15, 1912, 42 pupæ of the spanworm, spoken of in last year's report as having done serious damage on the Old Colony bog at Yarmouth, were collected. They were kept on moist sand in cans through the fall, winter and spring. Between June 6 and 15, 33 moths emerged from these pupæ, but no parasites were obtained from them. Three of the pupæ which failed to produce moths appeared to be in good condition and were probably killed by overheating a few days before the moths would have emerged. Of the 33 which emerged, 17 were females and 16 were males. These moths were protandrous in emerging, for before June 11, 13 males and only 8 females emerged, while after June 10, 9 females and only 3 males emerged.

The Old Colony bog was visited on June 13, and the moths of this insect were found to be present in great numbers on an area of about 2 acres (estimated) which had not been treated in any way to get rid of the insect because that portion of the bog belonged to a separate and apparently careless owner. It was estimated that three-fourths of the moths present were males, though the proportions of the sexes were not carefully ascertained. Portions of the bog, which had been heavily infested in July and August, 1912, had been burned over in the latter half of August, and other infested portions had been resanded with seven-eighths to one and one-half inches of sand. Practically no moths of the spanworm were found on June 13 on any of these treated portions, except where the treated areas immediately adjoined untreated heavily infested areas. Evidently the burning had effectively destroyed the pupæ and the sanding had smothered them.

It should be noted that, though the bog had been completely under water for over four months, the winter flowage had not drowned any considerable percentage of the pupæ. This seems remarkable, for they were entirely naked (*i.e.*, were without any cocoon), and they lay fully exposed on the surface of the sand. Practically all of these pupæ found on the bog on June 13 showed distinct signs of life when they were picked up.

At the time of the visit to this bog (June 13) the millers on the infested portion were being caught and eaten (the males mostly, as this sex flew up into the air readily, sometimes as high as 25 or 30 feet, while the females. as a rule, being heavy with eggs and unable to fly well, stumbled and flopped along the ground when attempting to do so) by swallows (two barn swallows and a dozen or more tree swallows). These swallows were flying back and forth like bats, and the clicking of their bills was incessant as they captured the moths.

On June 15 the eggs were dissected out of several plump female moths and counted. These eggs were all bright green in color when fresh from the moth, but they afterward turned yellowish. They numbered 295 in the most productive moth and 187 in the least productive one. Eggs of this insect were found hatching in the laboratory on June 19 and 20.

On July 8 the Old Colony bog was visited again, and the following notes concerning this insect were obtained from Mr. Ellis, the foreman of the bog, who seemed to be a very good observer: —

> The first worms of this insect were found on the bog on June 25. They were then very small. Unhatched eggs were also present in abundance on June 25. Small worms were seen in numbers spinning down the vines and hanging by small silken threads. Most of the moths had disappeared by June 18. The eggs on the vines were yellow and laid in scattering small batches (three to five together). The worms worked first on the backs of the leaves. On June 15 the female moths were more numerous and were scattered more widely over the bog than they were on the 13th, but the males were much less numerous on the 15th than they had been on the 13th. Females full of eggs were abundant on the 15th.

Mr. Ellis had been spraying a considerable part of the portion of the bog that was under his management, and his experience seemed to show that it is not very difficult to control this insect by thorough spraying with arsenate of lead.

On July 8 the worms (of many different sizes) were present on the badly infested portions of the bog in great numbers, the vines having been turned brown by their work and when opened appearing literally alive with them. So little foliage was left on the worst infested portions of the bog that death by starvation for a very large percentage of the worms seemed inevitable.

This insect was also found to be threatening a bog in Mattapoisett this year. Its scientific name is *Epelis truncataria* var. *faxonii* Minot. It has also been found feeding on the bearberry (*Arctostaphylos uva-ursi* L.).

A considerable number of parasites have been reared from the various cranberry pests, the names of which have not yet been determined. Some of these forms appear to represent species new to science. The species which have been named are listed in the following table: —

TABLE 5.

SCIENTIFIC NAME OF HOST.	Common Name of Host Insect.	Scientific Name of Parasite.	Order to which Parasite belongs.	Name of Expert who determined the Name of the Parasite.	Date of Emergence of the Parasite.	Number of Specimens obtained.	Stage of Host's Life-History from which reared.
1. *Peronea minuta* (Rob.),	Dry-bog fireworm,	*Exorista pyste* Walk.,	Diptera,	C. W. Johnson,	September 1 to 10.	10	Pupa.
		Phytodictus vulgaris Cress.,	Hymenoptera,	H. L. Viereck,	August 24, 1906.	1	–
		Pimpla conquisitor (Say.),	Hymenoptera,	H. L. Viereck,	– –	1	–
2. *Mincola vaccinii* (Riley),	Fruit worm,	*Phanerotoma tibialis* (Hald.),	Hymenoptera,	H. L. Viereck,	July 1 to 15.	Very many.	Larva.
		Microbrocon dorsator (Say.),	Hymenoptera,	H. L. Viereck,	July 2, 1907.	1	–
3. *Cymatophora sulphurea* Packard,	Spanworm,	*Ichneumon extrematatis* Cress.,	Hymenoptera,	H. L. Viereck,	– –	1	–
		Euphorocera claripennis Macq.,	Diptera,	C. W. Johnson,	– –	1	–
4. *Calocampa nupera* Lintner,	False army worm,	*Winthemia quadripustulata* F.,	Diptera,	C. W. Johnson,	July 23, 1906.	1	Pupa.
5.	Bud worm,	*Tachina robusta* Town,	Diptera,	C. W. Johnson,	– –	3	–

The Diptera listed in this table are named according to Aldrich's catalogue. Prof. C. W. Johnson of the Boston Society of Natural History has adopted changes in their names as follows: *Carcelia pyste* instead of *Exorista pyste; Phorocera claripennis* instead of *Euphorocera claripennis;* and *Exorista robusta* instead of *Tachina robusta.*

A small Trypetid was reared from cranberries in small numbers last year. Mr. F. L. Thomas, a graduate student at the Massachusetts Agricultural College who is making an exhaustive study of the Trypetidæ of New England, has determined this insect to be a small variety of the apple maggot (*Rhagoletis pomonella* Walsh).

Experimental Insect Work.

The experimental work with insects has been confined mostly to the flowed-bog fireworm (black head cranberry worm) and the fruit worm. The work with these two insects is here discussed in order.

The Flowed-bog Fireworm (*Rhopobota vacciniana* (Pack.)).

In last year's report on this insect, the successful results obtained in the treatment of a certain large bog by holding the winter flowage late (until June 2) and then reflowing about three weeks later to destroy an infestation were fully discussed. A somewhat similar procedure was carried out on another but smaller bog this season with much less satisfactory results, due probably to the fact that the reflowing was done too soon. The results of this treatment, all things considered, seemed, however, to be sufficiently successful to support the belief that where this method of treatment can be applied it will be found at least a fairly satisfactory one. The reflowage should evidently be continued for about forty-eight hours in this treatment.

The ideas advanced in last year's report, as to the way in which the bunching up of the hatching of the eggs of this insect is brought about by the late holding of the winter flowage, were evidently erroneous, as shown by observations made this year. Tests with thermometers made during the June reflows of the station bog showed that there are greater differences of temperature among the vines of a cranberry bog when the bog is flowed than when it is open to the air, the conditions in this respect being exactly the reverse of what they were last year presumed to be. It now seems probable that the bunching of the hatching by the late holding of the water is brought about mostly by a retardation or prohibition of hatching for the first eggs that reach or approach the hatching stage. It seems evident that the worms from any eggs, which might become far enough advanced to hatch under water, would drown soon after hatching, and it is not impossible that this is what really happens to the eggs soonest developed while the eggs of slower development are catching up with them as the warming up of the water in the late spring allows them to develop. It is, of course, evident that the whole hatching process is naturally more rapid under the hot sun of June than it is when the development of the eggs and their hatching takes place in the cooler weather of the first half of May, as usually occurs when the winter flowage is drawn off early.

The general position taken in last year's report in regard to the practice of spraying for this insect should probably be maintained. It seems possible, however, that instead of using Bordeaux mixture and Paris green for this spraying it will be found best to use arsenate of lead alone, for while some of the results with Bordeaux mixture have been satisfactory, there seem to be indications, as hinted in the discussion of the fungous work, that it may be, under some conditions at least, an injurious spray to use. Experiments are planned to find out more exactly about this. On some bogs where Bordeaux mixture and Paris green were used on one part and arsenate of lead on another, this year, the arsenate seemed to give rather distinctly better results.

We have not yet learned what is the best method of applying a spray to a cranberry bog. There is considerable diversity of opinion and experiments are planned along this line. It seems probable that in thick vines a spray driven with a good deal of force will place poison where it will have a more satisfactory effect in destroying this insect than will the poison of a spray lightly applied.

From observations made on a considerable number of bogs this year the fireworm seems to be distinctly more injurious on vines of the Late Howe variety than on those of the Early Black, and it seems probable that the late Howe is a favorite variety with the pest. If this is the case it is only an added indication that where bogs are being newly built it is the part of wisdom to plant only one variety on a bog. It is now becoming generally recognized that the planting of several varieties together on the same bog causes more or less serious inconvenience in many ways.

A detailed account was given in last year's report concerning the parasites and other natural enemies of this insect and concerning the bearing which bog flooding has upon their effective activity. In connection with this, attention should have been drawn to the fact that when a bog is reflowed after picking, the most conspicuous forms of animal life that are driven ashore by the water, from the standpoint of their numbers, are the spiders. The number of these forms seen by one looking for them on the occasion of such after-harvest reflowing is really surprising, and it is interesting to note that most of them, even on a bog of considerable size, succeed in reaching the upland alive, as they are fitted to float lightly upon the surface of the water for considerable distances if need be. In all his examinations of bogs made during the process of the after-harvest reflow the writer has as yet failed to see a sufficient number of parasitic insects driven up by the water to lead him to believe that they can have nearly as important a bearing on the prevalence of the fireworm as do the spiders. It is probable, however, that the presence of the parasites on a bog is, in a sense, more affected by the flowing than is that of the spiders, because they are probably far more liable to destruction by drowning than are the spiders, and, moreover, the parasites affecting the fireworm are probably more or less peculiar to it, while its spider enemies are presumably not so to any considerable extent.

The Fruit Worm (*Mineola vaccinii* (*Riley*)).

The chief work of the year with this insect has been a study of its natural enemies. Nearly a dozen species of its parasites have now been reared, and the complete life-history of the most important one was worked out in a general way. The connection of this parasitic insect with the fruit worm has not been heretofore suspected. Mr. H. L. Viereck, an expert on the group of insects to which it belongs, has determined it to be a Braconid, to which has been given the name *Phanerotoma tibialis* (Haldeman). This insect is seen on the cranberry bogs in large numbers every summer during and after the blooming period, but its presence has not been accounted for until now. This year it was seen in greatest numbers during the first three weeks of July. The adults had almost entirely disappeared from the bogs by July 26, it being possible to find only now and then one on that date.

A large number of wormy berries were collected during August, 1912, and kept in cans until Aug. 1, 1913. A careful record was made both of the moths and of the parasites which emerged from them. The wormy berries used in this investigation came from three general locations, as follows: —

1. The center of a flowed bog (station bog).
2. The edge of a flowed bog (station bog).
3. A dry bog (that is, one not flowed at any time).

The record of moth and parasite emergence was kept with these locations in mind. The most interesting points brought out by the record thus obtained were: —

1. That *Phanerotoma tibialis* far outnumbered all the other parasites taken together. All the parasites obtained from the berries collected at the center of the station bog, and all but one of those from the berries from the edge of this bog, were of this species. About four-fifths of the parasites from the berries collected from the dry bog were also of this species, but the percentage of other species of parasites was much greater among the forms obtained from the dry-bog berries than among those from the berries of the flowed bog.
2. The berries from the dry bog produced nearly three times as many parasites in proportion to the fruit-worm moths which emerged, as did the berries from any portion of the flowed bog.
3. The time of the greatest emergence of the parasites, from the berries from all three locations mentioned, was from June 30 to July 9, inclusive.
4. As slightly more parasites than moths emerged from the worms of the berries from the dry bog, it seems highly probable that more than 50 per cent. of the fruit worms on that bog last year were killed by these parasites. This shows something of the importance of the natural enemies of this insect which we have been in the habit of considering as being comparatively free from parasites.

It will be observed that the relative number of parasites obtained from the flowed bog and from the dry one shows a similar condition, as regards the amount of parasitism present on dry and flowed bogs, as that which has already been found to prevail with the natural enemies of the fireworm. From a study of the life-history of *Phanerotoma tibialis*, however, it is not easy to see just how the flowage can affect its prevalence to so marked an extent.

It was found that the adult *Phanerotoma* lays its egg in the egg of the fruit worm. It was not difficult to get one of these parasites to lay its egg under observation, by bringing near it a berry bearing, under one of the lobes of its blossom end, an unhatched fruit-worm egg. During their laying season these parasites are constantly running over the vines with actively vibrating antennæ, searching for the eggs of the fruit worm, and when a fruit-worm egg is presented to one of them, if the parasite's antennæ sense its location, it will give immediate attention to it, and the whole process of egg-laying may be observed. A peculiar fact discovered was that one of these parasites will never lay twice in the same fruit-worm egg. One of them can, however, be readily induced to lay an egg in a fruit-worm egg which already contains one or even several (twelve was the highest number reached in any test) eggs deposited by other individuals. It is not known whether the egg of the parasite hatches before the fruit-worm egg does or not, but at any rate the fruit worm when it emerges from the egg carries the small parasite with it, and as the fruit worm grows, the parasite within it also grows, feeding upon its juices and so depleting its vitality that when it becomes full grown and forms a cocoon around itself for the winter it is often but little more than half the size of a normal unparasitized worm. Some time during the winter or spring the parasite larva becomes full grown, and, emerging from the fruit worm, leaves it a mere dead shell, and forms its own tiny white cocoon about itself within the cocoon of the fruit worm. Within its cocoon it changes into the pupa stage, and it eventually emerges as an adult parasite nearly a year after it was deposited as an egg in the egg of the fruit worm.

The second most important parasite which was reared is a small Ichneumon, which lays its egg in the fruit worm after the worm has hatched and is already working in the berry. The name of this species has not yet been determined. The female in laying its egg inserts its egg-laying apparatus into the hole in the berry made and left open by the fruit worm. This parasite was never seen to drive its egg-laying apparatus through one of the white silken curtains which the worm usually makes over the mouth of its hole after going into its first or second berry. The life-history of this parasite has not yet been worked out to any extent. It is certainly a far less important enemy of the fruit worm than is *Phanerotoma tibialis*.

A large quantity of wormy berries was collected in August for the purpose of making a detailed study of some of the immature stages of these parasites, particularly of *Phanerotoma tibialis*.

Study of Control for Flowed Bogs.

No very definite advance in our ideas concerning the control of this pest by flooding was made during the year. The recommendations given in last year's report still stand with no substantial alteration. It was suspected that the depth of the flowage had some bearing on its effect in killing the worms within their cocoons, as it seemed reasonable to suppose that the greater water pressure of a deep flowage would be more effective in collapsing or penetrating the cocoons than would be the slight pressure of a shallow flowage. To test this, different lots of fruit worms, spun up naturally in their cocoons, were submerged to various depths in water contained in long glass tubes 2 inches in diameter. The following table, showing the results of some of these tests, is self-explanatory: —

Table 6.

Date submerged.	Date taken from Water.	Number submerged.	Depth of Submergence (Inches).	Cocoons occupied after Submergence.	Cocoons unoccupied after Submergence.	Number of Worms found Alive.	Number of Worms found Dead.
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	19	10	2	10	-
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	40	11	1	10	1 (?)
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	56	12	-	10	1[1]
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	68	12	-	10	2
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	9	80	9	-	8	1

It will be seen from this table that nine days of submergence, after the 8th of October, appeared to have but little effect on the worms at any depth tested. The remaining tests, not recorded in this table, gave results entirely similar. Possibly submergence earlier in the season would have been more effective in killing the worms. Bogs bearing late varieties could probably not, however, as a rule, be reflowed, after picking, before September 25, and it hardly seems probable that a difference of two weeks in the season would be sufficient to cause any marked difference in the effects of submergence on this insect. It may, of course, be possible to work in a flooding between the picking of the early and of the late varieties, but general experience appears to cast doubt upon the advisability of such a program.

An interesting fact learned while making these submergence tests was that the cocoons of the fruit worm are not at all impervious to water. When carefully opened, after only a few minutes' submergence, they were found to be wet inside, the water having apparently penetrated them almost immediately. It now seems evident that the cocoon protects the worm by preventing the escape of the vesicle of air which it contains, which the worm needs more than anything else in order to survive, rather than by keeping out the water by any imperviousness of its texture.

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[1] And 1 doubtful.

Study of Control for Dry Bogs.

The sanding experiment conducted last year to determine whether this insect could be smothered in its cocoon was repeated and continued this year on the same heavily infested bog, but the general results were unsatisfactory. It now seems pretty certain that this method of treatment for this insect will never be practicable.

In last year's report suggestions were made concerning the possibility of starving out fruit-worm infestations on dry bogs by killing the remnant of the bloom, in seasons of severe winter-kill injury or of severe frost damage, by spraying with a 20 per cent. solution of iron sulphate. First tests of the practicability of this method of treatment were made this year, and it was found that this solution can be used in such a way as to kill the bloom without apparent injury either to the vines or to the buds forming for the succeeding year's growth. It was necessary, however, to apply three rather thorough sprayings to accomplish the entire destruction of the blossom, because of the fact that the blossoming does not all take place at one time but is extended through a period of three or four weeks. The necessity of three sprayings instead of one has brought in a new element of danger which must be considered in connection with the practicability of this treatment. In making the 20 per cent. solution of iron sulphate 100 pounds of the chemical are used to every 50 gallons of water. It takes not less than 150 gallons to spray an acre thoroughly. This means that with each application 300 pounds of the iron sulphate would be put on each acre. Three applications would therefore deposit nearly half a ton of this chemical, per acre, on the bog. It seems probable that this amount of iron sulphate might injure the cranberry root system and perhaps kill the vines. Further experiments to determine about this are planned. If there proves to be no danger in this way, it seems probable that this method of treatment may be used to advantage on dry bogs.

8. WEEDS.

Horse-tail (*Equisetum* spp.) is one of the most troublesome weeds with which the cranberry grower has to contend. In general the growers show more concern over this weed than they do about any other. For this reason some attention was given to experimenting with it during the year. Solutions of copper sulphate as strong as 1 pound to 25 gallons of water were injected into a bog where this weed was growing in abundance to depths ranging from 6 inches to 2 feet, the solution being poured into holes a foot apart each way, made with a crow bar, a quart of the solution being used in each hole. Unfortunately, this treatment did not seem to affect the horse-tail injuriously, but rather seemed to cause it to thrive instead.

Thorough spraying with a 20 per cent. iron sulphate solution was fairly effective in killing back the tops of the weed, but there is, as has been already noted under the fruit-worm discussion, a possible danger connected with the continued use of this chemical on the same area.

9. RESANDING.

Plots O and V, spoken of in last year's report, were again left without resanding this year, while the surrounding bog was also not resanded. Three new plots, N, R and T, were laid out and resanded on Oct. 17, 1912, while the surrounding bog was not resanded again. All these plots were picked with scoops in 1913, and checks on each were laid out and picked for comparison. The following table is, in this connection, self-explanatory: —

TABLE 7.

PLOT.	Area of Plot (Square Rods).	Date picked.	Quantity of Fruit obtained (Bushels).	Percentage of Loss in Storage Tests.	Variety.
O,	9	Sept. 8	$12\frac{1}{2}$	$29\frac{2}{5}$	Early Black.
O (check 1),	9	Sept. 8	15	$28\frac{9}{10}$	Early Black.
O (check 2),	9	Sept. 8	$19\frac{1}{2}$	-	Early Black.
V,	9	Sept. 6	$18\frac{1}{6}$	$36\frac{3}{4}$	Early Black.
V (check 1),	9	Sept. 6	22	$41\frac{2}{10}$	Early Black.
V (check 2),	9	Sept. 6	$18\frac{2}{3}$	-	Early Black.
N,	9	Sept. 4	20	$38\frac{1}{4}$	Early Black.
N (check 1),	9	Sept. 4	$15\frac{1}{6}$	$30\frac{1}{7}$	Early Black.
N (check 2),	9	Sept. 4	25	-	Early Black.
N (check 3),	9	Sept. 4	$23\frac{1}{2}$	-	Early Black.
R,	9	Sept. 9	17	36	Early Black.
R (check 1),	9	Sept. 9	$16\frac{3}{4}$	$34\frac{2}{10}$	Early Black.
R (check 2),	9	Sept. 9	18	-	Early Black.
T,	9	Sept. 28	$20\frac{1}{2}$	$38\frac{3}{4}$	Howe.
T (check 1),	9	Sept. 28	19	$29\frac{2}{5}$	Howe.
T (check 2),	9	Sept. 28	23	-	Howe.

It will be seen from the above table that plots O and V showed a distinct falling off in quantity of fruit, due to the prolonged lack of resanding. Plots N, R and T, however, gave no increase in fruit over their checks, probably because the previous resanding of the general bog (fall of 1911) was still sufficient to maintain the vines in very good condition. Berries from all these plots and their checks were tested for keeping quality, the period of storage extending from October 28 to about December 20 on the average, there being a variation of five days in the time of final screening, with the results given in the above table. The berries of the checks on each plot were mixed so as to have a single storage check in each case. The check storage figures given in the table, therefore, represent the mixture rather than the first check alone with which they are in each case associated. As the table shows, the berries of the unsanded plots, O and V, kept somewhat better on the average than did those of their checks, while the berries of the sanded plots, N, R and T, all showed a poorer keeping quality than did those of their checks. The results of these tests, therefore, substantiate the findings of last year.

10. MISCELLANEOUS.

During the fall the possibility of introducing cranberry vines for holiday decorations for dining rooms was investigated. A patch of Late Howe vines was left unpicked and was so protected from frost until into November, by covering with canvas, that it kept in good green condition. Some of these vines were cut and several wreaths and other decorations, bearing the natural fruit, were made from them, a damp moss foundation being used in every case. From the standpoint of beauty these decorations probably could not be easily surpassed, and there seemed for a time to be a considerable promise of success for them. It was found eventually, however, that even though plunged in wet moss the vines did not endure the heat of warm rooms for more than two or three days before they deteriorated badly in appearance. It became evident, therefore, that cranberry vines could not be used successfully in this way. Possibly, however, a satisfactory decoration could be made up by putting them in gold-fish jars for table ornamentation.

The results of the following spraying tests are of general interest, the spray in every case having been applied on a cranberry bog on the 29th of July: —

1. Plot sprayed with a mixture made up as follows: copper sulphate, 2 pounds; lime, 1½ pounds; resin fish-oil soap, 1 pound; arsenate of lead, 3 pounds; water, 25 gallons. No injury was later observed to have been caused by the application of this spray.

2. Plot sprayed with a mixture made up as follows: lime, 1½ pounds; resin fish-oil soap, 2 pounds; arsenate of lead, 3 pounds; water, 25 gallons. No injury was observed as a result of this application.

3. Plot sprayed with the following mixture: resin fish-oil soap, 2 pounds; arsenate of lead, 3 pounds; water, 25 gallons. The vines on this plot were badly burned by the treatment.

The interesting point shown by these three tests is that resin fish-oil soap and arsenate of lead cannot safely be used together as a spray unless lime is added. This confirms the general result of tests made in previous years, but not reported upon.

A plot was picked by hand in the three years 1911, 1912 and 1913 successively, the quantity of fruit it produced in comparison with the surrounding bog being carefully noted each year, the general result being that no distinct advantage was shown for hand picking, from the standpoint of the quantity of fruit obtained.

The Station Bog Crop.

The bog bore a heavy crop this year, averaging about 100 barrels to the acre. This was probably largely due to the rest which the vines obtained because of last year's light crop. More water was pumped for irrigation this year than in 1912, but on the whole the bog was nevertheless run fairly dry throughout the season, the ditches not being held full of water for more than a day or two at a time. There is probably a limit beyond which a bog may become too dry if it is not irrigated. It seems probable that the wisest course to pursue, in irrigating a bog during the growing season, is to try to be sure that it has what water it needs, but that it is not given moisture much in excess of its needs. It is probably better to give a bog a good wetting occasionally and then draw off the surplus water, so that the ditches shall be fairly empty, than it is to keep the ditches full for any considerable period of time during the growing season and so run the risk of injuring the root system. The year's observations have confirmed those of last year in showing that the higher and better drained portions of a bog usually produce more fruit than the low portions. Blocks of vines from different parts of flowed and dry bogs were cut out during the season, and their root systems were washed out and examined, it being discovered from this that, while on dry bogs there is often a well-developed root growth running deep into the peat, the root system of flowed bogs is apparently always confined for the most part to the sand above the peat. It seems likely that this condition on the flowed bogs has been brought about by root drowning caused by holding the water table too high during periods of root growth. A mere examination, therefore, of the amounts of fruit borne by high and low portions of a bog is probably not sufficient to justify any certain conclusion concerning the causes of differences noted in the amount of fruit produced, for while a season's drainage is one possible important factor, the development of the root system, brought about by the conditions of previous seasons, is perhaps as likely to have a powerful influence on the ability of the plant to withstand drought, and therefore produce fruit under extreme conditions.

A Needed Investigation.

We are coming to understand something of the factors bearing directly on the portion of the cranberry plant which is above ground. While it is important to understand these more easily observed agencies bearing on the welfare of the plant, it seems certain that some of the most important things which influence cranberry growth and fruiting have been almost entirely neglected in our studies up to the present time. A knowledge of the special physiology of the plant, especially of the development and activities of its root system, seems to be very greatly needed. The seasonal development of the root system of most plants begins fairly early in the spring and is nearly coincident with the development of the portions of the plant above ground. Recent investigations [1] by Professor Coville, of the Bureau of Plant Industry of the United States Department of Agriculture, have shown that with the blueberries, which are closely related to the cranberry, there is no new root growth until the plants have developed both their leaves and their blossoms. If this is also the rule in the development of the cranberry, it may have a rather vital bearing on the practices to be observed in the flooding and irrigation of cranberry bogs. A lot of vines have already been potted in earthen pots for this and other studies, and it is planned to pot more in glass pots, so that the growth of the root system may be directly observed in all its stages and in all seasons.

NOTES ON THE WATER OF CRANBERRY BOGS.[2]

Since 1910 the experiment station has been studying the properties and movements of the water in cranberry bogs, in order to determine the probable losses of fertility in the drainage water, because the bogs are generally flooded throughout the winter and sometimes for brief periods during the summer, as a protection against frost and insects.

The problem of fertilizing cranberry bogs to improve the crop is complicated by this periodical flowage and drainage. Many cranberry growers think that fertilizers are wasted if applied to the bogs, while actual field experiments in Massachusetts, New Jersey and Wisconsin have shown a positive benefit by a light top-dressing of soluble chemicals, namely, nitrates, superphosphates and potash salts.

The small experimental cranberry bogs in which the studies have been made were devised by Director Brooks, who has described them fully elsewhere.[3] It is deemed sufficient for this article to say that each bog is contained in an upright cylinder 24 inches in diameter and 48 inches in depth, constructed of glazed sewer tile bedded in concrete. Each bog is connected by a brass pipe passing through the concrete, with a smaller cylinder of similar construction, 6 inches in diameter and of the same depth as the bog. The small tile corresponds to the drainage ditch in the field, and is provided with an outlet and stopcock 12 inches below the level of the surface of the bog. By means of the smaller cylinder the bog can be drained or irrigated at will, and the depth of the water-level below the surface can be observed at any time.

At the approach of winter the bogs are fitted with galvanized iron rims cemented in place with an asphaltum cement, by which the water-level over the bogs may be raised to a height of about 12 inches. To prevent freezing and bursting the cylinders the entire set of bogs is covered with a removable roof of boards which is further covered by cornstalks and hay to a depth sufficient to completely protect the interior from external temperature. As soon as freezing weather is over in the spring the covering of litter is removed, and later, at the proper season for draining the bogs, the roof is taken away.

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[1] Experiments in Blueberry Culture," by Frederick V. Coville, 1911. Bulletin No. 193 of the Bureau of Plant Industry, United States Department of Agriculture.

[2] By Fred W. Morse.

[3] Proc. Soc. Promotion Agri. Sci., 1911, pp. 23-28.

The drainage from a cranberry bog consists of two quite distinct portions, namely, the run-off from the surface and the seepage from the soil, while there is the ditch water at the beginning of drainage, which is a mixture of both kinds. On a properly graded bog nearly all the surface flowage should run directly into the ditches without seeping through the soil. On the other hand, water retained by the vines and in depressions in the surface of the bog, together with the water held in the pore-space of the sand and peat above the level of the sluice gates, must either evaporate or sink lower into the bog, and as it settles it displaces the saturated bog water, which seeps into the ditches.

The composition of the three types of drainage water has been carefully followed season by season, and it is believed that some light has been obtained on the probable losses of fertility.

The surface water is removed from the experimental bogs by means of a dipper, because their construction does not permit it to be drawn off otherwise without losing its identity. Its composition has been found to be essentially like any surface water from ponds and streams. The surface waters from four bogs that had been top-dressed with a complete fertilizer in 1911 were examined in the spring of 1912, in comparison with the surface water from four bogs which had received no fertilizer. Total solids and organic solids were first determined with the following results: surface water contained in 100,000 parts, 16.0 parts total residue and 4.8 parts organic matter from the fertilized bogs while the surface water from the unfertilized bogs contained 19.2 parts total residue and 6.4 parts organic matter. No nitrates were found, and as the fertilized bogs had not imparted any increase of soluble matter to their flood waters it was not deemed worth while to carry the analysis further. The run-off cannot be considered as removing from the bogs any serious amount of fertility, since its composition cannot vary widely from the water when applied, except for the soluble matter that is extracted from the vines.

The water standing in the small cylinders at the time the surface water was dipped from the bogs is nearly the counterpart of the ditch water after the run-off has past and seepage begins. That is, it is a mixture of surface water and seepage water. A number of analyses have been made of the water at this stage, because there are possibilities for considerable variation, and it will be noted in the table that there is a wide range between the two seasons.

TABLE 1. — *Composition of Ditch Water.*

[Parts in 100,000.]

BOG.	MAY 4 AND 9, 1912.		
	Total Residue.	Organic Matter.	Total Nitrogen.
8 (A and B),	71.1	38.6	1.42
9 (A and B),	64.3	33.6	1.38
14 (A and B),	56.2	26.2	1.15
15 (A and B),	52.3	26.3	1.36

BOG.	MAY 8 AND 9, 1913.			
	Total Residue.	Organic Matter.	Total Nitrogen.	Potash.
4 (A and B),	37.0	12.2	0.28	-
5 (A and B),	38.0	11.4	0.40	3.8
6 (A and B),	40.4	10.8	0.56	3.1
7 (A and B),	56.2	15.2	0.90	4.6
8 (A and B),	60.6	14.4	0.91	4.7
9 (A and B),	46.8	13.0	0.45	3.6
10 (A and B),	65.2	17.4	0.56	-
12 (A and B),	56.8	15.8	0.91	-

To estimate the probable losses from a bog it would be necessary to know the capacity of the ditches, since the small cylinders in our experiments bear a much larger proportion to the bog's surface than occurs in field practice.

The average content of nitrogen in the ditch water was 1.33 parts in 100,000 in 1912, and 0.62 part in 100,000 in 1913. Potash was determined only in 1913, when the average content was 3.96 parts in 100,000. Fifty thousand gallons of ditch water, containing 0.98 part of nitrogen and 3.96 parts of potash in 100,000 parts of water, would carry away a trifle more than 4 pounds of nitrogen and 16 pounds of potash. It would also be equivalent in volume to the water contained in a ditch 3 feet deep, 2 feet wide and a little over 67 rods long, which would be more ditch than is usually employed on an acre of cranberry bog.

The mixture of surface and seepage water in the small cylinder of the experimental bogs may or may not closely resemble similar water in the ditches of large bogs. It is the writer's opinion that the latter water would be even more dilute, since a sample of ditch water collected at the experimental bog in East Wareham contained only 21.3 parts of total solids and 12.1 parts of organic solids in 100,000 parts of water at a time when Dr. H. J. Franklin, the superintendent of the bog, deemed the ditch water to be at its normal state, with no irrigation water mixed with it. There was but 0.28 part of total nitrogen in 100,000 parts, and bare traces of phosphates and potash in this water.

The seepage water, which is practically the same thing as the saturated soil water from the interior of the peat, is noticeably uniform in composition throughout the season, and the average composition for 1912 is very close to that of 1911, published in the twenty-fourth annual report.[1]

TABLE 2. — *Composition of Seepage Water, 1912.*

Total Residue and Organic Matter.

[Parts in 100,000.]

Bog.	May 14.		May 22.		June 10.		June 17.	
	Total Residue.	Organic Matter.	Total Residue.	Organic Matter.	Total Residue.	Organic Matter.	Total Residue.	Organic Matter.
8 (A and B),	101.0	53.0	114.8	52.0	–	–	109.4	60.6
9 (A and B),	91.4	50.6	118.4	54.2	–	–	114.0	63.4
10 (A and B),	119.4	62.8	144.5	75.1	–	–	132.0	74.4
12 (A and B),	95.0	51.0	111.4	51.4	113.0	62.8	–	–
13 (A and B),	98.6	52.0	124.2	59.2	91.8	63.4	–	–
14 (A and B),	102.0	50.2	137.2	76.0	134.6	67.2	–	–
15 (A and B),	105.5	54.4	122.1	62.7	104.2	57.2	120.0	67.4

Fertility Constituents.

[Parts in 100,000.]

Bog.	Total Nitrogen.					Phosphoric Acid.		Potash.	
	May 14.	May 22.	June 10.	June 17.	June 25.	May 22.	June 10.	May 22.	June 10.
8 (A and B),	2.45	3.04	–	2.66	–	–	–	–	–
9 (A and B),	2.13	3.08	–	2.52	–	–	–	–	–
10 (A and B),	3.01	3.96	–	3.36	3.38	–	1.78	7.75	–
12 (A and B),	2.27	3.15	2.94	–	3.05	1.19	1.55	7.44	–
13 (A and B),	2.38	3.22	2.90	–	2.69	1.17	–	7.29	6.15
14 (A and B),	2.27	3.32	–	–	3.01	1.14	1.48	–	8.12
15 (A and B),	2.59	3.43	3.32	2.73	–	–	2.00	–	6.62

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[1] Mass. Agr. Sta., 24th An. Rept., Pt. I., p. 220.

The amount of this seepage must vary from season to season. The spring seasons of 1912 and 1913 were unusually wet for about three weeks after the surfaces of the bogs were drained, and several rains made it necessary to open repeatedly the stopcocks in the drainage cylinders. The amount of seepage determined by the amount of water which flowed through the outlets amounted to 25.6 quarts per bog in 1912 and 24.5 quarts in 1913, or, in round numbers, a little over 90,000 gallons per acre in the first year and over 85.000 gallons in the second, or an average weight of over 700,000 pounds of water per acre, which would contain, discarding fractions, more than 21 pounds nitrogen, 10 pounds of phosphoric acid and 50 pounds of potash.

There was no evidence that the application of fertilizers in the previous year caused any increase in these substances.

Fertilizer Scheme for Bogs.

Bogs numbered 6, 10, 11 and 14 receive no fertilizers.
Bog numbered 1 received nitrate of soda.
Bog numbered 2 received acid phosphate.
Bog numbered 3 received sulfate of potash.
Bog numbered 4 received nitrate and phosphate.
Bog numbered 5 received nitrate and potash.
Bog numbered 7 received phosphate and potash.
Bogs numbered 8, 9, 12, 13 and 15 receive all three substances.

The period of seepage was succeeded in both seasons by a short space of time during which the water-level fluctuated within narrow limits, and following this interval was a prolonged dry season during which it was necessary to add water repeatedly to the small cylinders to replace the amount of water evaporated from the surface of the bogs. The addition of this water gradually changed the composition of the water in the cylinders until it showed that practically all of the original seepage water had been reabsorbed by the peat. This showed that there was no apparent diffusion from bog to cylinder, and there must be actual movement of water from the bog to cause any loss to the bog of its soluble matter.

The permanent losses of fertility are limited to the seepage water which actually flows away from the ditches into the main drain or stream passing through a bog. They cannot be avoided; but there is no evidence that the small additions of chemicals in the late spring increase the losses any.

The amount of water required for irrigation was determined in both years by measuring the quantities added from time to time to the small cylinders. These cylinders were kept covered with galvanized iron caps, so that evaporation and rainfall would affect only the surface of the bogs. Water was added on seven different dates in the summer of 1912, beginning with July 3 and ending on August 16. In 1913 there were eleven different dates beginning with June 19 and ending on August 28.

The total amount added in 1912 was 13.75 gallons per bog, equivalent to a depth of 7 inches over the surface, while in the yet drier season of 1913, 23.75 gallons were required per bog, or a depth of 12 inches.

During 1912 it was noticeable that some bogs evaporated much more rapidly than others; but the actual differences were not determined. In the fall, before putting on the sheet-iron rims, it was necessary to cut off the vines which extended over the wall of the tile, and also to cut out some of the surplus growth within the bog area. These prunings were dried and weighed, and were found to vary much. There also appeared to be some relationship between the weight of prunings and the rate of water movement in the bogs, which was to be expected, since transpiration should increase with the development of the vines.

Therefore in 1913 a careful record was kept of the amounts of water removed from individual bogs as drainage water in the spring and the quantities of irrigation water added during the summer. The results, together with the weight of vines removed the previous fall, are given in Table 3, as follows: —

TABLE 3. — *Relation between Drainage, Irrigation and Vine Growth.*

BOG.	Drainage (Quarts).	Irrigation (Quarts).	Vines (Grams).	BOG.	Drainage (Quarts).	Irrigation (Quarts).	Vines (Grams).
6A,	25.1	88.0	190.7	6B,	21.5	103.0	184.2
10A,	21.0	98.0	187.1	10B,	28.5	107.0	295.8
14A,	19.5	95.0	185.2	14B,	18.4	85.0	140.5
11A,	3.1	64.0[1]	38.0	11B,	23.5	96.0	184.3
2A,	28.9	102.0	123.2	2B,	30.0	113.0	221.7
3A,	24.5	100.0	165.4	3B,	28.9	120.0	238.9
7A,	22.9	85.0	124.1	7B,	28.2	114.0	298.3
1A,	10.8	85.0	98.5	1B,	6.4	62.0	91.4
4A,	32.0	117.0	258.9	4B,	31.3	117.0	302.1
5A,	28.1	101.0	213.9	5B,	23.3	96.0	216.6
8A,	23.6	89.0	186.8	8B,	25.6	98.0	226.6
9A,	23.3	83.0	187.8	9B,	24.8	93.0	221.8
12A,	27.1	100.0	252.5	12B,	28.3	103.0	235.4
13A,	25.3	92.0	173.3	13B,	25.6	93.0	214.3
15A,	30.9	93.0	231.2	15B,	22.9	85.0	173.0

Excluding 1A, 1B and 11A, the averages for 27 bogs are: drainage, 25.6 quarts; irrigation, 98.7 quarts; vines, 208.8 grams.

The bogs are arranged so that the unfertilized ones, 6, 10, 11 and 14, head the columns, followed by 2, 3 and 7 with no nitrogen, while 1, 4 and 5 receive nitrogen in nitrate of soda, and 8, 9, 12, 13 and 15 are dressed with complete fertilizers, including nitrates.

It will be noted that neither nitrogen nor other fertilizers were responsible for large vine growth, but that in 12 out of 14 bogs having vine growth above the average, the drainage from the bogs in the spring was above the average, and in 10 cases the irrigation was high also. On the other hand, bogs 1A, 1B and 11A, in which the water movement was notably slow, yielded the smallest weights of vines when pruned.

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[1] Water applied to surface of bog.

In a large proportion of the bogs the growth of vines appeared to be related to the freedom with which the soil permitted the water to move from bog to drain and back again. Not only was more water evaporated during the summer, but these bogs permitted rapid percolation or seepage in the spring into the small cylinders. The bogs with small vine growth were slow to drain in the spring, and much of the water evaporated from the surface of the bog instead of seeping into the drainage cylinder.

In conclusion our observations show that the principal losses of fertility are in the seepage water which may escape from the ditches, and that the vine growth is more influenced by the free movement of water than by fertilizers.

The assistance of Mr. R. W. Ruprecht in measuring the water, and of Mr. R. L. Coffin in pruning and weighing the vines, is gratefully acknowledged.

THE DETERMINATION OF ACETYL NUMBER.[1]

EDW. B. HOLLAND.

Introduction.

The various hydroxy compounds that occur in oils, fats and waxes form derivatives on heating with acetic anhydride, the acetyl radical displacing the hydrogen of the alcoholic hydroxyl groups. This property serves as the basis of analytical methods for the quantitative determination of these compounds. The proposed acetyl number indicates the milligrams of potassium hydroxide required for the saponification of the acetyl assimilated by one gram of an oil, fat or wax on acetylation.[2] On saponifying with alcoholic potash the acetyl is hydrolyzed to acetic acid and combines with the alkali to form potassium acetate. The results are expressed in terms of milligrams of potassium hydroxide to conform with the general practice in fat analysis. The compounds involved are monohydroxy and dihydroxy acids and their glycerides, — monoglycerides and diglycerides and free alcohols.

Use of the Test.

In the examination of oils and fats a determination of acetyl number is necessary, in most instances, for a thorough understanding of the nature and quality of the product. Some of the hydroxy compounds are natural and others are the result of hydrolysis or of oxidation. Glycerides of hydroxy acids are a natural constituent of certain oils and fats, although they do not appear to be very widely distributed in any considerable amount. Castor oil, composed largely of ricinolein, is a notable illustration. Hydroxy acids probably occur more frequently as the result of oxidation of unsaturated acids. Oleic acid has been shown repeatedly to be comparatively unstable. By the assimilation of oxygen and water it may be converted into dihydroxystearic acid, a saturated compound.

$$C_{17}H_{33}COOH + H_2O + O = C_{17}H_{33}(OH)_2COOH.$$

Whether the oxidation takes place in the glycerides or in the fatty acids after hydrolysis is uncertain, although the latter appears the more probable supposition.

Monoglycerides and diglycerides result from the hydrolysis of triglycerides, and free fatty acids condition their presence. The absence of free fatty acids in a commercial product, however, does not necessarily preclude the presence of monoglycerides and diglycerides.

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[1] The writer is pleased to acknowledge many suggestions and helpful criticisms by Dr. J. S. Chamberlain, Mr. F. W. Morse, Mr. J. C. Reed and Mr. J. P. Buckley.

[2] Benedikt and Ulzer, and Lewkowitsch report on the basis of the acetylated product.

Solid alcohols of the cyclic series (sterols) occur in oils and fats both in combination as esters and as free alcohols.[1] The amount of cholesterol or phytosterol is generally small, often inappreciable, and is indicated approximately by the unsaponifiable matter which it characterizes. Alcohols of the ethane and other series, free and in combination, compose a considerable proportion of waxes.

Oils and fats, therefore, may contain glycerides of monohydroxy and dihydroxy acids, possibly free hydroxy acids, monoglycerides and diglycerides and free alcohols; and the insoluble acids, separated from the oils and fats, may contain monohydroxy and dihydroxy acids and free alcohols. A portion, at least, of the free alcohols found in the insoluble acids probably occurred in the fat as esters. With the exclusion of the natural glycerides of hydroxy acids and a small amount of free alcohols, the acetyl number of many oils and fats may be deemed an index of quality, and when considered in conjunction with the acid and iodine numbers may serve to measure (more or less imperfectly, to be sure) the amount of hydrolysis and of oxidation the product has undergone. To differentiate between products of hydrolysis and of oxidation the acetyl number of the insoluble acids should also be determined.

Earlier Methods.

The several analytical processes that have been offered are based on the same chemical reactions, but differ in application and in details of procedure. The original method was devised by Benedikt and Ulzer[2] and applied to the insoluble acids. The acetyl number indicated the milligrams of potassium hydroxide required to neutralize the acetic acid obtained on saponifying one gram of acetylated insoluble fatty acids, and was determined by the difference between the acid and saponification numbers of the acetylated acids (acetyl ether number). The actual procedure consisted in saponifying the acetylated acids after neutralizing in alcohol. Lewkowitsch[3] has shown, however, that the results so obtained were generally in excess of the true values, due to the conversion of a part of the fatty acids on heating with a large excess of acetic anhydride into their anhydrides, as illustrated by the following equation: —

$$\underset{\text{fatty acid}}{2\,RCOOH} + \underset{\text{acetic anhydride}}{(CH_3CO)_2O} = \underset{\text{anhydride of fatty acid}}{(RCO)_2O} + \underset{\text{acetic acid}}{2\,CH_3COOH}$$

These fatty anhydrides are fairly stable compounds, but may become hydrolyzed to some extent on washing with boiling water. Subsequent treatment with cold alcohol in the determination of the acetyl acid number will continue the hydrolysis, although a portion is likely to remain unchanged, thereby yielding too low an acid number, due to the inability of the anhydrides to combine with alkali. As complete hydrolysis occurs on saponification, the acetyl (ether) number would be too high and even appear when none exists.

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[1] See numerous references: Abderhalden, Physiological Chemistry (1908); Hammarsten, Physiological Chemistry (1911); Leathes, The Fats (1910).

[2] Monatsh. Chem., 8, pp. 41–48 (1887).

[3] Analysis of Oils, Fats and Waxes, 1, pp. 344, 345 (1909).

Lewkowitsch[1] proposed the acetylation of the natural product. In conformity thereto the acetyl number indicates the milligrams of potassium hydroxide required for the neutralization of the acetic acid obtained on saponifying one gram of an acetylated oil, fat or wax. This method requires the saponification of the acetylated fat and the determination of the resulting acetic acid by either a filtration or distillation process. The former process is an adaptation of the regular method for the direct determination of soluble acids, and the latter process is a modified Reichert-Meissl test, with repeated distillation of the aqueous solution until the distillate is free from acids. The presence of natural soluble or volatile acids necessitates a similar treatment of the unacetylated fat in order to determine the amount of alkali assimilated by those acids for which proper corrections.must be made to obtain the true acetyl number. The occurrence of the lower acids makes the determination a long and tedious operation.

PROPOSED METHOD.

Analytical methods for the examination of oils and fats is a subject that has been given considerable study by the writer in connection with feeding experiments and other investigations made at the Massachusetts Agricultural Experiment Station. During the past few years the determination of acetyl number has received particular attention with a view to evolving a process that might be free from the objections cited for the Benedikt and Ulzer, and Lewkowitsch methods. Believing that this end has been attained in some measure, a report of progress is now offered in the hope that it may lead to further improvement.

The custom of reporting acetyl number on the basis of the acetylated product appears unwarranted. It is contrary to general practice in analytical work and is the exception in fat analysis. The definition[2] here adopted places the acetyl number on a par with other tests, and is as follows: the acetyl number indicates the milligrams of potassium hydroxide required for the saponification of the acetyl assimilated by one gram of an oil, fat or wax on acetylation.

METHOD IN DETAIL.

The development of the method extended over a period of several years, and finally resolved into an adaptation of several well-known processes. For instance, ceresine is used to solidify the acetylated fat so that it may be washed by decantation as in the determination of insoluble acids. The saponification number of the acetylated fat is determined by the same process as that of the original fat, and the difference measures the amount of acetyl that has been assimilated. The process may be appropriately described as a method by analogy.

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[1] *Loco citato*, 1, pp. 337, 338 (1909).

[2] The hydroxyl value of Twitchell is reported in a similar manner. Jour. Amer. Chem. Society, 29, pp. 566–571 (1907).

The reagents employed in the determination are summarized so that their application may be clearly understood: —

Acetic anhydride, Kahlbaum's.
Ceresine, pure white, filtered.
Alcohol, redistilled, free from acids and aldehydes.
Alcoholic potash, 50 c.c. of a saturated solution of potassium hydroxide, free from carbonate, to 1,000 c.c. of alcohol. The solution should be allowed to stand at least twenty-four hours and filtered immediately before use.
$N/_2$ hydrochloric acid.
Alkali blue (6B), 1 gram to 100 c.c. of alcohol. The indicator should be digested in a stoppered bottle for several days at room temperature, with occasional shaking, and then filtered.
Phenolphthalein, 1 gram to 100 c.c. of alcohol, neutralized.

After what has been said, the details of the method should be so evident as to require no further explanation.

Into a 300 c.c. Erlenmeyer flask are brought 5 grams of fat, together with 10 c.c. of acetic anhydride. The flask is connected with a spiral or other form of reflux condenser and heated in a boiling water bath (immersed in the water) for from one to one and one-half hours. Longer heating yields higher results, but is accompanied by partial decomposition of the fat with formation of aldehydes or other bodies that give a reddish color with caustic alkali. . After acetylating, the flask is removed from the bath and sufficient ceresine added to form, with the fat, a solid disc when chilled in cold water. The amount of ceresine required will vary with the consistency of the product under examination. For butter fat .4 to .5 grams is ample; for softer fats and oils rather more; and for harder fats, less. The flask is heated on the water bath and the contents rotated until the ceresine and acetylated fat form a homogeneous mixture. One hundred and fifty c.c. of boiling water are then poured carefully into the flask with as little disturbance of the fat layer as possible, and the solution heated on the bath with occasional agitation to remove occluded acetic acid. The flask is immersed in cold water to solidify the ceresine-fat, after which the solution is decanted through a dense, ether-extracted filter, care being taken not to break the insoluble cake. Another 150 c.c. of boiling water are added, thoroughly agitated, heated as above, cooled and decanted, the process being repeated until the final filtrate gives a decided color with two or three drops of $N/_{10}$ alkali, using phenolphthalein as indicator (about six times). Prolonged washing is likely to cause slight dissociation of the acetylated product.

The filter and inverted flask containing the cake of ceresine-fat are allowed to drain in a cool place until practically dry. The small particles adhering to the filter are then scraped into the flask, and 50 c.c. of alcoholic potash, accurately measured with a burette, 50 c.c. of alcohol and several glass beads added. The flask is connected with a spiral or other form of reflux condenser and the solution boiled on a water bath until saponification is complete, — about sixty minutes. The flask is placed in a water bath at 60° C. and the solution, after cooling to that temperature, titrated with $N/_2$ hydrochloric acid, using 1 c.c. of alkali blue as indicator. Phenolphthalein may be employed, though less satisfactory for colored solutions. The alcoholic mixture is again brought to boil to free any alkali occluded in the ceresine, and retitered if necessary. Several blank determinations should be run with every series of tests under precisely similar conditions as to time and treatment, except that the ceresine may be omitted. However, every lot of ceresine must be tested, should be free from soluble matter and not assimilate any alkali on saponification. The difference between the titration of the blank and that of the excess alkali in the test is the acid equivalent of the fat after acetylation, which should be calculated to milligrams of potassium hydroxide for 1 gram of fat.

One c.c. of $N/_2$ acid is equivalent to 28.054 milligrams of potassium hydroxide. The difference between the saponification number of the fat before and after acetylation is the acetyl number. In case the original fat contains *free soluble* acids, their titer should be determined and proper correction made for the same.

Limit of error, 0.50 acetyl number.

Synopsis of Reaction.

A better conception of the method may be obtained by a summary of the reactions: —

Acetylation of glycerides of monohydroxy and dihydroxy acids, monoglycerides and diglycerides and free alcohols. (See formulas.)
Saponification of the acetylated product. (See formulas.)
Saponification of the original or unacetylated product.
Titration of excess alkali.
Acetyl number by difference.

Glycerides of Monohydroxy and Dihydroxy Acids.

Acetylation: —

$$\underset{\substack{\text{triglyceride of}\\\text{monohydroxy acid}}}{(R.OH.COO)_3C_3H_5} + \underset{\substack{\text{acetic}\\\text{anhydride}}}{3(CH_3CO)_2O} = \underset{\substack{\text{acetylated}\\\text{glyceride}}}{(R.OCH_3CO.COO)_3C_3H_5} + \underset{\substack{\text{acetic}\\\text{acid}}}{3\,CH_3COOH}$$

Example: Ricinolein $(C_{17}H_{32}.OH.COO)_3C_3H_5$

Saponification: —

$$\underset{\text{acetylated glyceride}}{(R.OCH_3CO.COO)_3C_3H_5} + \underset{\text{alkali}}{6\,KOH}$$

$$= \underset{\substack{\text{potassium}\\\text{salt of hydroxy acid}}}{3\,R.OH.COOK} + \underset{\substack{\text{potassium}\\\text{acetate}}}{3\,CH_3COOK} + \underset{\text{glycerol}}{C_3H_5(OH)_3}$$

$$\underset{\substack{\text{triglyceride of}\\\text{dihydroxy acid}}}{[R(OH)_2COO]_3C_3H_5} + (CH_3CO)_2O = \underset{\text{acetylated glyceride}}{[R(OCH_3CO)_2COO]_3C_3H_5} + H_2O$$

Example: Dihydroxystearin $[C_{17}H_{33}(OH)_2COO]_3C_3H_5$

$$[R(OCH_3CO)_2COO]_3C_3H_5 + 9\,KOH = 3\,R(OH)_2COOK + 6\,CH_3COOK + C_3H_5(OH)_3$$

Monoglycerides and Diglycerides.

$$\underset{\text{monoglyceride}}{(RCOO)C_3H_5(OH)_2} + (CH_3CO)_2O = \underset{\text{diaceto-glyceride}}{(RCOO)(CH_3COO)_2C_3H_5} + H_2O$$

$$(RCOO)(CH_3COO)_2C_3H_5 + 3\,KOH = RCOOK + 2\,CH_3COOK + C_3H_5(OH)_3$$

$$\underset{\text{diglyceride}}{(RCOO)_2C_3H_5(OH)} + (CH_3CO)_2O = \underset{\text{monaceto-glyceride}}{(RCOO)_2(CH_3COO)C_3H_5} + CH_3COOH$$

$$(RCOO)_2(CH_3COO)C_3H_5 + 3\,KOH = 2\,RCOOK + CH_3COOK + C_3H_5(OH)_3$$

Free Alcohols.

$$\underset{\text{monobasic alcohol}}{ROH} + (CH_3CO)_2O = \underset{\text{acetate of alcohol}}{CH_3COOR} + CH_3COOH$$

$$CH_3COOR + KOH = ROH + CH_3COOK$$

Examples: Cholesterol, phytosterol, $C_{27}H_{45}OH$

Considerable variation is possible in writing the above formulas which, at best, poorly express the structure. In some instances the reaction is indicated at some sacrifice of form.

Calculated Data from the Acetyl Number.

The acetyl number (c) serves to measure the amount of hydroxy compounds in an oil, fat or wax; and in case only one such compound of known molecular weight (m) and number of hydroxyls (d) is present, its amount (H) can be readily calculated by the following formula: —

$$H = \frac{cm}{56108\ d}$$

The derivation of the formula is comparatively simple. The theoretical acetyl number of a compound containing (d) hydroxyl groups is —

$$\frac{56108\ d}{m}$$

The amount of such a compound in an oil, fat or wax is, therefore —

$$\frac{c}{\frac{56108\ d}{m}} = \frac{cm}{56108\ d}$$

The same results may be calculated more easily from the following table, dividing the determined acetyl number by the theoretical acetyl number, or multiplying by its reciprocal: —

Acetyl Number on Original Product (Massachusetts Method).

Glycerides.

NAME.	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Ricinolein, . .	$(C_{17}H_{32} . OH . COO)_3C_3H_5$, .	932.832	180.444	180.444	.0055419
Dihydroxystearin, .	$[C_{17}H_{33}(OH)_2COO]_3C_3H_5$, .	986.880	170.562	341.124	.0029315
	Monoglycerides.				
Monopalmitin, .	$(C_{15}H_{31}COO)C_3H_5(OH)_2$, .	330.304	169.868	339.736	.0029435
Monostearin, .	$(C_{17}H_{35}COO)C_3H_5(OH)_2$, .	358.336	156.579	313.159	.0031933
Monolein, . .	$(C_{17}H_{33}COO)C_3H_5(OH)_2$, .	356.320	157.465	314.930	.0031753

Acetyl Number on Original Product (Massachusetts Method) — Con.

Diglycerides.

NAME.	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Dipalmitin,	$(C_{15}H_{31}COO)_2C_3H_5(OH)$,	568.544	197.374	98.687	.0101330
Distearin,	$(C_{17}H_{35}COO)_2C_3H_5(OH)$,	624.608	179.658	89.829	.0111323
Diolein,	$(C_{17}H_{33}COO)_2C_3H_5(OH)$,	620.576	180.826	90.413	.0110604
	Hydroxy Acids.				
Ricinoleic,	$C_{17}H_{32} . OH . COOH$,	298.272	188.110	188.110	.0053160
Dihydroxystearic,	$C_{17}H_{33}(OH)_2COOH$,	316.288	177.395	354.791	.0028186
	Free Alcohols.				
Cholesterol,	$C_{27}H_{45}OH$,	386.368	–	145.219	.0068862
Phytosterol,	$C_{27}H_{45}OH$,	386.368	–	145.219	.0068862

GRAVIMETRIC PROCESS.[1]

After acetylating, a gravimetric process for acetyl number may be conducted in a manner similar to that for the quantitative determination of insoluble fatty acids, observing all the precautions therein noted as to ceresine, washing, drying, weighing, etc.

This modification is apparently rather more difficult, tedious and subject to error than the saponification or volumetric process (Massachusetts method). A certain amount of loss arises from the dehydration of free fatty acids by acetic anhydride during acetylation, and is difficult to prevent, although of little consequence where the amount of free acids is relatively small.

The acetyl number (a) is calculated from the increase in weight (i) by the following formula: —

$$a = \frac{56108\ i}{42.016} \text{ or } 1335.39604\ i$$

In case only one hydroxy compound of known molecular weight (m) and number of hydroxyls (d) is present, its amount can be calculated from the increase in weight (i) of the oil, fat or wax on acetylating. The theoretical increase for a hydroxy compound is —

$$\frac{42.016\ d}{m}$$

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[1] This process has not received sufficient study in this laboratory to warrant positive statements, but is similar to the methods described by Lewkowitsch (*loco citato*), 1, pp. 358–363, 466, 467.

The amount (H) of such a compound in an oil, fat or wax is therefore —

$$H = \frac{i}{\frac{42.016\,d}{m}} \text{ or } \frac{im}{42.016\,d}$$

Molecular Weight of Hydroxy Compounds.

The molecular weight of the hydroxy compounds can be calculated from the weight (w) of fat taken and the increase (i) on acetylating, provided the number (d) of hydroxyls in the molecule is known: —

$$w : w + i = m : m + 42.016\,d$$

$$m = \frac{42.016\,dw}{i}$$

The formation of anhydrides during the acetylating process will affect the accuracy of these calculations.

The computation of the amount of hydroxy compounds by the gravimetric process is greatly facilitated by use of the following table: —

Acetyl Gravimetric Process on Original Product.

Glycerides.

Name.	Molecular Weight.	Molecular Weight after Acetylating.	Theoretical Increase in Weight per Gram on Acetylating.[1]	Reciprocal.
Ricinolein,	932.832	1058.880	.135124	7.40061
Dihydroxystearin,	986.880	1238.976	.255447	3.91471
Monoglycerides.				
Monopalmitin,	330.304	414.336	.254408	3.93069
Monostearin,	358.336	442.368	.234506	4.26428
Monolein,	356.320	440.352	.235833	4.24029
Diglycerides.				
Dipalmitin,	568.544	610.560	.073901	13.53162
Distearin,	624.608	666.624	.067268	14.86591
Diolein,	620.576	662.592	.067705	14.76996
Hydroxy Acids.				
Ricinoleic,	298.272	340.288	.140865	7.09900
Dihydroxystearic,	316.288	400.320	.265682	3.76390
Free Alcohols.				
Cholesterol,	386.368	428.384	.108746	9.19574
Phytosterol,	386.368	428.384	.108746	9.19574

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[1] Acetyl number = 1335.39604 i.

Acetyl Number of Insoluble Fatty Acids.

The acetyl number of the insoluble fatty acids is determined by the Massachusetts method in precisely the same way as that of the original fat. The gravimetric process is not applicable on account of the formation of anhydrides of the fatty acids. The method for preparing the stock of insoluble acids for analysis is the same as that for the determination of "Insoluble Acids," with the elimination of such features as are necessary only for quantitative work.

In order to interpret the results satisfactorily it is necessary to know the percentage of insoluble acids so that the acetyl number of the acids may be considered in conjunction with the acetyl number of the fat.

RESULTS BY DIFFERENT METHODS.

For convenience, the theoretical acetyl numbers of some hydroxy compounds by the Benedikt and Ulzer, and Lewkowitsch methods are tabulated to permit comparison with the acetyl numbers by the Massachusetts and gravimetric processes previously stated. When only one hydroxy compound of known composition is present in an oil or fat the results can be readily converted from the basis of the original to that of the acetylated product and vice versa. In other cases conversion is generally impracticable on account of the marked differences in assimilation of acetyl by the several classes of hydroxy compounds. Formulas may show the relation, however, that the results by different methods bear to each other, (m) indicating the molecular weight of the hydroxy compound, (d) the number of hydroxyls, and (i) the increase in weight on acetylating: —

Massachusetts Method.

$$\frac{cm}{56108\ d}$$

Gravimetric Method.

$$\frac{im}{42.016\ d}$$

Benedikt and Ulzer, and Lewkowitsch Methods.

$$\frac{c(m + 42.016\ d)}{56108\ d}$$

Acetyl Number on Acetylated Product. (Benedikt and Ulzer, and Lewkowitsch Methods.)

Glycerides.

NAME (ACETYLATED).	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Ricinolein,	$(C_{17}H_{32} . OCH_3CO . COO)_3C_3H_5$,	1058.880	317.928	158.964	.0062907
Dihydroxystearin,	$[C_{17}H_{33}(OCH_3CO)_2COO]_3C_3H_5$,	1238.976	407.572	271.715	.0036803
Monoglycerides.					
Monopalmitin,	$(C_{15}H_{31}COO)\ (CH_3COO)_2C_3H_5$,	414.336	406.250	270.833	.0036923
Monostearin,	$(C_{17}H_{35}COO)\ (CH_3COO)_2C_3H_5$,	442.368	380.507	253.671	.0039421
Monolein,	$(C_{17}H_{33}COO)\ (CH_3COO)_2C_3H_5$,	440.352	382.249	254.832	.0039242
Diglycerides.					
Dipalmitin,	$(C_{15}H_{31}COO)_2(CH_3COO)C_3H_5$,	610.560	275.688	91.896	.0108819
Distearin,	$(C_{17}H_{35}COO)_2(CH_3COO)C_3H_5$,	666.624	252.502	84.167	.0118811
Diolein,	$(C_{17}H_{33}COO)_2(CH_3COO)C_3H_5$,	662.592	254.039	84.680	.0118092
Hydroxy Acids.					
Ricinoleic,	$C_{17}H_{32}. OCH_3CO . COOH$,	340.288	329.768	164.884	.0060649
Dihydroxystearic,	$C_{17}H_{33}\ (OCH_3CO)_2COOH$,	400.320	420.474	280.316	.0035674
Free Alcohols.					
Cholesterol,	$CH_3COO\ C_{27}H_{45}$,	428.384	–	130.976	.0076350
Phytosterol,	$CH_3COO\ C_{27}H_{45}$,	428.384	–	130.976	.0076350

RÉSUMÉ.

The acetyl numbers of a fat and of the insoluble acids afford valuable information relative to the nature and the quality of a product. Apparently many analysts have been deterred from making the determinations on account of the time required, tedious manipulation involved or inability to interpret the results. The proposed method is comparatively short and simple and readily understood because of its similarity to other fat methods in common use. It is practically free from the objections cited for the earlier methods, and the results are directly comparable with other fat determinations, being on the same basis.

THE DIGESTIBILITY OF CATTLE FOODS.

BY J. B. LINDSEY AND P. H. SMITH.

Foreword.

The digestion experiments herein reported were made during the autumn, winter and early spring of 1910–11, 1911–12, 1912–13 and also, two experiments, in the autumn of 1913. They form part of what are known as Series XVI., XVII., XVIII. and XIX. The experiments made in these series and not here included have either been published in previous reports or will be found in later publications.

The usual method was employed and has been fully described elsewhere.[1] The full data are here presented, with the exception of the daily production of manure and the daily water consumption, in which cases, to economize space, averages only are given. The periods extended over fourteen days, the first seven of which were preliminary, collection of feces being made during the last seven. Ten grams of salt were given each sheep daily with water *ad libitum.* The sheep used in these experiments were grade Shropshires of substantially uniform weight, born in 1907.

1. Series XVI.

The hay used in connection with this series consisted of fine mixed grasses, and contained a large proportion of June grass (*Poa pratensis*). The digestion coefficients of this hay, as obtained in Period I., were applied to the two experiments on beet pulp which follow: —

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[1] Eleventh report of the Mass. State Agr. Exp. Sta., pp. 146–149; also the 22d report of the Mass. Agr. Exp. Sta., p. 84.

Composition of Feedstuffs (Per Cent).

[Dry Matter.]

FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
English hay, Period I.,	7.47	9.58	30.98	49.36	2.61
English hay, Period II.,	6.96	9.90	31.39	49.13	2.62
English hay, Period III.,	6.66	9.64	30.76	50.46	2.48
Waste, Sheep I., Period I.,	8.89	5.86	36.92	46.94	1.39
Molasses dried beet pulp,	5.56	11.68	16.40	65.89	.47
Plain dried beet pulp,	3.29	8.12	20.46	67.76	.37

Composition of Feces (Per Cent).

[Dry Matter.]

Sheep I.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	13.61	11.82	25.82	45.49	3.26
II.	Molasses dried beet pulp,	13.15	15.27	24.46	43.03	4.09
III.	Dried beet pulp,	12.20	13.49	25.81	44.63	3.87

Sheep II.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	13.37	11.13	28.27	44.32	2.91
II.	Molasses dried beet pulp,	13.67	15.69	25.10	41.87	3.67
III.	Dried beet pulp,	11.98	12.37	27.55	44.25	3.85

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent).

Sheep I.

PERIOD.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Waste.	Feces.
I.,	88.55	–	–	83.40	93.62
II.,	89.85	89.60	–	–	92.25
III.,	90.90	–	89.64	–	88.83

Sheep II.

PERIOD.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Waste.	Feces.
I.,	88.55	–	–	–	93.57
II.,	89.85	89.60	–	–	92.47
III.,	90.90	–	89.64	–	89.02

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep I.

Period.	CHARACTER OF FOOD OR RATION.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay, ...	627	27.600	1,512
II.	Molasses dried beet pulp, ...	684	23.470	1,893
III.	Dried beet pulp, ...	695	26.097	1,829

Sheep II.

Period.	CHARACTER OF FOOD OR RATION.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay, ...	1,032	30.768	2,465
II.	Molasses dried beet pulp, ...	983	24.881	2,611
III.	Dried beet pulp, ...	605	27.486	1,946

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds).

Sheep I.

Period.	CHARACTER OF FOOD OR RATION.	BEGINNING.		END.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay, ...	122.00	121.75	120.00	119.00
II.	Molasses dried beet pulp, . . .	128.25	126.50	125.25	126.25
III.	Dried beet pulp, ...	126.25	127.00	125.25	125.00

Sheep II.

Period.	CHARACTER OF FOOD OR RATION.	BEGINNING.		END.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay, ...	125.00	128.50	126.50	126.50
II.	Molasses dried beet pulp, . . .	142.25	141.50	140.25	140.00
III.	Dried beet pulp, ...	140.75	139.75	138.50	138.50

English Hay, Period I.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed daily, .	708.40	52.92	67.86	219.46	349.67	18.49
13.75 grams waste, ...	11.47	1.02	.67	4.23	5.39	.16
Amount consumed, ...	696.93	51.90	67.19	215.23	344.28	18.33
276.03 grams manure excreted, . .	258.42	35.17	30.55	66.72	117.56	8.42
Grams digested, ...	438.51	16.73	36.64	148.51	226.72	9.91
Per cent. digested, ...	62.92	32.24	54.53	69.00	65.85	54.06

English Hay, Period I — Concluded.

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed daily, .	708.40	52.92	67.86	219.46	349.67	18.49
307.68 grams manure excreted, . .	287.90	38.49	32.04	81.39	127.60	8.38
Grams digested, ...	420.50	14.43	35.82	138.07	222.07	10.11
Per cent. digested, ...	59.36	27.27	52.79	62.91	63.51	54.68
Average per cent. for both sheep, .	61.14	29.76	53.66	65.96	64.68	54.37

Average nutritive ratio of rations for both sheep, 1:10.7.

Molasses Dried Beet Pulp, Period II.

Sheep I.

500 grams English hay fed, . .	449.25	31.27	44.48	141.02	220.71	11.77
300 grams molasses dried beet pulp fed,	268.80	14.94	31.40	44.08	177.12	1.26
Amount consumed, ...	718.05	46.21	75.88	185.10	397.83	13.03
234.70 grams manure excreted, . .	216.51	28.47	33.06	52.96	93.16	8.86
Grams digested, ...	501.54	17.74	42.82	132.14	304.67	4.17
Minus hay digested, ...	274.04	9.38	24.02	93.07	143.46	6.36
Molasses dried beet pulp digested, .	227.50	8.36	18.80	39.07	161.21	-
Per cent. digested, ...	84.64	55.96	59.87	88.63	91.02	-

Sheep II.

Amount consumed as above, . .	718.05	46.21	75.88	185.10	397.83	13.03
248.81 grams manure excreted, . .	230.07	31.45	36.10	57.75	96.33	8.44
Grams digested, ...	487.98	14.76	39.78	127.35	301.50	4.59
Minus hay digested, ...	274.04	9.38	24.02	93.07	143.46	6.36
Molasses dried beet pulp digested, .	213.94	5.38	15.76	34.28	158.04	-
Per cent. digested, ...	79.57	36.01	50.19	77.77	89.23	-
Average per cent. for both sheep, .	82.11	45.99	55.03	83.20	90.13	-

Average nutritive ratio of rations for both sheep, 1:10.7.

Dried Beet Pulp, Period III.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	499.95	33.30	48.20	153.78	252.27	12.40
250 grams dried beet pulp fed,	224.10	7.37	18.19	45.86	151.85	.83
Amount consumed,	724.05	40.67	66.39	199.64	404.12	13.23
260.97 grams manure excreted,	231.82	28.28	31.27	59.83	103.47	8.97
Grams digested,	492.23	12.39	35.12	139.81	300.65	4.26
Minus hay digested,	304.97	9.99	26.03	101.49	163.98	6.70
Dried beet pulp digested,	187.26	2.40	9.09	38.32	136.67	-
Per cent. digested,	76.72	32.56	49.97	83.56	90.00	-

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	724.05	40.67	66.39	199.64	404.12	13.23
274.86 grams manure excreted,	244.68	29.31	30.27	67.41	108.27	9.42
Grams digested,	479.37	11.36	36.12	132.23	295.85	3.81
Minus hay digested,	304.97	9.99	26.03	101.49	163.98	6.70
Dried beet pulp digested,	174.40	1.37	10.09	30.74	131.87	-
Per cent. digested,	71.45	18.59	55.47	67.03	86.84	-
Average per cent. for both sheep,	74.09	25.58	52.72	75.30	88.42	-

Average nutritive ratio of rations for both sheep, 1:12.4.

2. SERIES XVII.

Digestion Coefficients of Basal Ration used in this Series.

[English Hay.]

	Periods I.-VII.	Periods VIII.-X.
Dry matter,	62	65
Ash,	34	46
Protein,	55	65
Fiber,	68	67
Nitrogen-free extract,	65	67
Fat,	48	46

Composition of Feedstuffs (Per Cent).

[Dry Matter.]

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	7.75	9.06	31.65	49.16	2.38
II.	English hay, ...	7.51	9.44	31.73	48.96	2.36
II.	Cocoanut meal, ...	6.97	21.17	9.23	52.58	10.05
III.	English hay, ...	8.19	10.36	30.46	48.37	2.62
III.	Cottonseed feed meal, Creamo brand,	5.28	23.75	21.22	44.32	5.43
IV.	English hay, ...	7.65	10.02	32.48	47.58	2.27
IV.	Wheat screenings, ...	5.19	17.20	10.52	60.05	7.04
V.	English hay, ...	6.92	10.17	30.65	49.92	2.34
V.	Molasses dried beet pulp, . . .	5.69	11.44	15.88	66.72	.27
V.	Dried beet pulp, ...	3.16	8.01	27.22	61.38	.23
VI.	English hay, ...	6.26	9.50	32.52	49.18	2.54
VI.	Flax shives, ...	5.59	16.54	35.90	38.75	3.22
VII.	English hay, ...	7.13	9.85	30.91	49.66	2.45
VII.	Cocoanut meal, ...	6.06	21.58	9.83	52.42	10.11
VIII.	English hay, ...	6.73	10.37	30.18	49.84	2.88
IX.	English hay, ...	5.70	9.90	30.50	51.03	2.87
IX.	Cocoa shells, ...	8.83	14.55	13.25	58.23	5.14
X.	English hay, ...	5.46	9.40	31.35	50.77	3.02
X.	Wheat screenings, ...	4.28	17.50	8.29	64.66	5 27

Composition of Feces (Per Cent).

[Dry Matter.]

Sheep I.

IX.	Cocoa shells, ...	10.88	15.09	26.20	44.45	3.38

Sheep II.

IX.	Cocoa shells, ...	10.94	14.13	25.14	46.38	3.41

Sheep III.

V.	Dried beet pulp, ...	12.31	13.00	20.13	50.50	4.06

Sheep IV.

IV.	Molasses dried beet pulp, . . .	12.17	13.00	27.00	43.82	4.01

Composition of Feces (Per Cent.) — Concluded.

Sheep V.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	13.65	10.80	27.32	45.04	3.19
III.	Cottonseed feed meal, Creamo brand,	12.25	13.11	28.23	43.89	2.52
IV.	Wheat screenings, ...	12.07	10.95	28.21	45.89	2.88
VI.	Flax shives, ...	9.66	9.20	35.55	43.26	2.33
VII.	Cocoanut meal, ...	12.12	11.51	28.81	44.74	2.82
VIII.	English hay, ...	9.87	10.30	28.36	47.35	4.12
X.	Wheat screenings, ...	10.48	11.74	28.47	45.35	3.96

Sheep VI.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	13.50	10.68	26.56	45.88	3.38
II.	Cocoanut meal, ...	13.24	11.93	27.40	44.57	2.86
III.	Cottonseed feed meal, Creamo brand,	11.93	12.50	29.55	43.37	2.65
IV.	Wheat screenings, ...	12.36	10.79	27.77	46.20	2.88
VI.	Flax shives, ...	9.91	9.27	34.88	43.55	2.39
VII.	Cocoanut meal, ...	12.48	11.22	28.80	44.71	2.79
VIII.	English hay, ...	10.88	10.53	27.61	46.21	4.47
X.	Wheat screenings, ...	11.22	11.96	28.54	44.40	3.88

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep I.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Cocoa Shells.	Feces.
IX., ...	89.20	–	–	95.47	92.18

Sheep II.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Cocoa Shells.	Feces.
IX., ...	89.20	–	–	95.47	92.38

Sheep III.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Cocoa Shells.	Feces.
V., ...	92.97	–	90.92	–	94.91

Sheep IV.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Cocoa Shells.	Feces.
V., ...	92.97	94.04	–	–	94.85

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.) — Concluded.

Sheep V.

Period.	English Hay.	Cocoanut Meal.	Cotton-seed Feed Meal.	Wheat Screenings.	Flax Shives.	Feces.
I.,	88.50	-	-	-	-	93.30
III.,	87.57	-	89.70	-	-	93.77
IV.,	89.45	-	-	91.94	-	95.41
VI.,	93.25	-	-	-	90.02	95.16
VII.,	90.70	92.86	-	-	-	93.68
VIII.,	90.67	-	-	-	-	92.94
X.,	89.47	-	-	88.52	-	93.11

Sheep VI.

Period.	English Hay.	Cocoanut Meal.	Cotton-seed Feed Meal.	Wheat Screenings.	Flax Shives.	Feces.
I.,	88.50	-	-	-	-	93.25
II.,	87.82	88.37	-	-	-	93.52
III.,	87.57	-	89.70	-	-	94.06
IV.,	89.45	-	-	91.94	-	95.44
VI.,	93.25	-	-	-	90.02	95.18
VII.,	90.70	92.86	-	-	-	93.75
VIII.,	90.67	-	-	-	-	93.03
X.,	89.47	-	-	88.52	-	93.32

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep I.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	Cocoa shells,	898	28.76	2,168

Sheep II.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	Cocoa shells,	661	28.40	2,510

Sheep III.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
V.	Dried beet pulp,	590	26.33	1,975

Sheep IV.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
V.	Molasses dried beet pulp,	708	24.75	2,482

Average Daily Amount of Manure excreted and Water drunk (Grams) — Concluded.

Sheep V.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay,	559	29.30	971
III.	Cottonseed feed meal, Creamo brand,	554	29.08	1,493
IV.	Wheat screenings,	586	29.55	951
VI.	Flax shives,	752	35.84	1,691
VII.	Cocoanut meal,	580	27.13	1,839
VIII.	English hay,	583	27.93	1,902
X.	Wheat screenings,	739	26.85	2,202

Sheep VI.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay,	554	28.07	1,474
II.	Cocoanut meal,	498	25.50	1,403
III.	Cottonseed feed meal, Creamo brand,	570	29.40	2,011
IV.	Wheat screenings,	583	28.95	2,165
VI.	Flax shives,	685	34.67	2,806
VII.	Cocoanut meal,	556	26.31	3,141
VIII.	English hay,	536	26.97	3,289
X.	Wheat screenings,	662	26.09	3,494

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
IX.	Cocoa shells,	146.50	144.00	142.50	142.50

Sheep II.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
IX.	Cocoa shells,	143.50	142.50	143.00	143.00

Sheep III.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
V.	Dried beet pulp,	160.00	158.75	162.00	160.50

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds) — Concluded.

Sheep IV.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
V.	Molasses dried beet pulp,	164.50	163.00	163.00	162.50

Sheep V.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay,	163.25	163.25	159.25	160.75
III.	Cottonseed feed meal, Creamo brand,	158.25	159.25	158.25	156.50
IV.	Wheat screenings,	158.75	158.00	159.50	157.00
VI.	Flax shives,	168.50	167.50	164.75	164.75
VII.	Cocoanut meal,	167.50	169.75	165.50 163.25	163.00 166.25
VIII.	English hay,	163.50	161.50	162.50	161.50
X.	Wheat screenings,	162.00	161.50	158.50	157.50

Sheep VI.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay,	146.75	146.75	146.75	147.00
II.	Cocoanut meal,	146.75	145.00	143.50	145.50
III.	Cottonseed feed meal, Creamo brand,	141.50	142.00	141.00	139.25
IV.	Wheat screenings,	143.00	142.00	141.25	139.50
VI.	Flax shives,	156.50	157.00	154.25	154.50
VII.	Cocoanut meal,	151.50	151.50	153.50 152.50	152.00 150.00
VIII.	English hay,	151.00	151.75	152.00	150.50
X.	Wheat screenings,	150.00	149.50	148.00	148.25

English Hay, Period I.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	708.00	54.87	64.14	224.08	348.06	16.85
293 grams manure excreted,	273.37	37.32	29.52	74.68	123.13	8.72
Grams digested,	434.63	17.55	34.62	149.40	224.93	8.13
Per cent. digested,	61.39	31.98	53.98	66.67	64.62	48.25

English Hay, Period I — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, . .	708.00	54.87	64.14	224.08	348.06	16.85
280.67 grams manure excreted, . .	261.72	35.33	27.95	69.51	120.08	8.85
Grams digested, ...	446.28	19.54	36.19	154.57	227.98	8.00
Per cent. digested, ...	63.03	35.61	56.42	68.98	65.50	47.48
Average per cent. for both sheep, .	62.21	33.80	55.20	67.83	65.06	47.87

Average nutritive ratio of rations for both sheep, 1:11.2.

Cocoanut Meal, Period II.

Sheep VI.

650 grams English hay fed, . .	570.83	42.87	53.87	181.13	279.49	13.47
150 grams cocoanut meal fed, . .	132.56	9.24	28.06	12.24	69.70	13.32
Amount consumed, ...	703.39	52.11	81.93	193.37	349.19	26.79
255 grams manure excreted, . .	238.48	31.57	28.45	65.34	106.30	6.82
Grams digested, ...	464.91	20.54	53.48	128.03	242.89	19.97
Minus hay digested, ...	353.91	14.58	29.63	123.17	181.67	6.47
Cocoanut meal digested, . . .	111.00	5.96	23.85	4.86	61.22	13.50
Per cent. digested, ...	83.74	64.50	85.00	39.71	87.83	101.35

Average nutritive ratio of ration, 1:7.8.

Cottonseed Feed Meal, Creamo Brand, Period III.

Sheep V.

600 grams English hay fed, . .	525.42	43.03	54.43	160.04	254.15	13.77
200 grams cottonseed feed meal fed, .	179.40	9.47	42.61	38.07	79.51	9.74
Amount consumed, ...	704.82	52.50	97.04	198.11	333.66	23.51
290.8 grams manure excreted, . .	272.68	33.40	35.45	76.98	119.68	6.87
Grams digested, ...	432.14	19.10	61.59	121.13	213.98	16.64
Minus hay digested, ...	325.76	14.63	29.94	108.83	165.20	6.61
Cottonseed feed meal digested, . .	106.38	4.47	31.65	12.30	48.78	10.03
Per cent. digested, ...	59.30	47.20	74.28	32.31	61.35	102.97

Cottonseed Feed Meal, Creamo Brand, Period III — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	704.82	52.50	97.04	198.11	333.66	23.51
293.99 grams manure excreted,	276.53	32.99	34.57	81.71	119.93	7.33
Grams digested,	428.29	19.51	62.47	116.40	213.73	16.18
Minus hay digested,	325.76	14.63	29.94	108.83	165.20	6.61
Cottonseed feed meal digested,	102.53	4.88	32.53	7.57	48.53	9.57
Per cent. digested,	57.15	51.53	76.34	19.88	61.04	98.25
Average per cent. for both sheep,	58.23	49.37	75.31	26.10	61.20	100.61

Average nutritive ratio of rations for both sheep, 1:5.94.

Wheat Screenings, Period IV.

Sheep V.

600 grams English hay fed,	536.70	41.06	53.78	174.32	255.36	12.18
200 grams wheat screenings fed,	183.88	9.54	31.63	19.34	110.42	12.95
Amount consumed,	720.58	50.60	85.41	193.66	365.78	25.13
295.54 grams manure excreted,	281.97	34.03	30.88	79.54	129.40	8.12
Grams digested,	438.61	16.57	54.53	114.12	236.38	17.01
Minus hay digested,	332.75	13.96	29.58	118.54	165.98	5.85
Wheat screenings digested,	105.86	2.61	24.95	–	70.40	11.16
Per cent. digested,	57.57	27.36	78.88	–	63.76	86.18

Sheep VI.

Amount consumed as above,	720.58	50.60	85.41	193.66	365.78	25.13
289.51 grams manure excreted,	276.31	34.15	29.81	76.73	127.66	7.96
Grams digested,	444.27	16.45	55.60	116.93	238.12	17.17
Minus hay digested,	332.75	13.96	29.58	118.54	165.98	5.85
Wheat screenings digested,	111.52	2.49	26.02	–	72.14	11.32
Per cent. digested,	60.65	26.19	82.97	–	65.33	87.41
Average per cent. for both sheep,	59.11	26.73	80.93	–	64.55	86.80

Average nutritive ratio of rations for both sheep, 1:7.1.

Dried Beet Pulp, Period V.

Sheep III.

—	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	511.34	35.39	52.00	156.73	255.25	11.97
250 grams dried beet pulp fed,	227.30	7.18	18.21	61.87	139.52	.52
Amount consumed,	738.64	42.57	70.21	218.60	394.77	12.49
263.27 grams manure excreted,	249.87	30.76	32.48	50.30	126.19	10.14
Grams digested,	488.77	11.81	37.73	168.30	268.58	2.35
Minus hay digested,	317.03	12.03	28.60	106.58	165.91	5.75
Dried beet pulp digested,	171.74	–	9.13	61.72	102.67	–
Per cent. digested,	75.56	–	50.14	99.76	73.59	–

Average nutritive ratio of ration, 1:11.7.

Molasses Dried Beet Pulp, Period V.

Sheep IV.

550 grams English hay fed,	511.34	35.39	52.00	156.73	255.25	11.97
250 grams molasses dried beet pulp fed,	235.10	13.38	26.90	37.33	156.86	.63
Amount consumed,	746.44	48.77	78.90	194.06	412.11	12.60
247.50 grams manure excreted,	234.75	28.57	30.52	63.38	102.87	9.41
Grams digested,	511.69	20.20	48.38	130.68	309.24	3.19
Minus hay digested,	317.03	12.03	28.60	106.58	165.91	5.75
Molasses dried beet pulp digested,	194.66	8.17	19.78	24.10	143.33	–
Per cent. digested,	82.80	61.06	73.53	64.56	91.37	–

Average nutritive ratio of ration, 1:9.2.

Flax Shives, Period VI.

Sheep V.

600 grams English hay fed,	559.50	35.02	53.15	181.95	275.17	14.21
250 grams flax shives fed,	225.05	12.58	37.22	80.79	87.21	7.25
Amount consumed,	784.55	47.60	90.37	262.74	362.38	21.46
358.38 grams manure excreted,	341.03	32.94	31.37	121.24	147.53	7.95
Grams digested,	443.52	14.66	59.00	141.50	214.85	13.51
Minus hay digested,	346.89	11.91	29.23	123.73	178.86	6.82
Flax shives digested,	96.63	2.75	29.77	17.77	35.99	6.69
Per cent. digested,	42.94	21.86	79.98	22.00	41.27	92.26

Flax Shives, Period VI — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	784.55	47.60	90.37	262.74	362.38	21.46
346.74 grams manure excreted, . .	330.03	32.71	30.59	115.11	143.73	7.89
Grams digested, ...	454.52	14.89	59.78	147.63	218.65	13.57
Minus hay digested, ...	346.89	11.91	29.23	123.73	178.86	6.82
Flax shives digested, ...	107.63	2.98	30.55	23.90	39.79	6.75
Per cent. digested, ...	47.82	23.69	82.08	29.58	45.63	93.09
Average per cent. for both sheep, .	45.38	22.78	81.03	25.79	43.45	92.68

Average nutritive ratio of rations for both sheep, 1:6.6.

Cocoanut Meal, Period VII.

Sheep V.

650 grams English hay fed, . .	589.55	42.03	58.07	182.23	292.78	14.44
150 grams cocoanut meal fed, . .	139.29	8.44	30.06	13.69	73.02	14.08
Amount consumed, ...	728.84	50.47	88.13	195.92	365.80	28.52
271.34 grams manure excreted, . .	254.19	30.81	29.26	73.23	113.72	7.17
Grams digested, ...	474.65	19.66	58.87	122.69	252.08	21.35
Minus hay digested, ...	365.52	14.29	31.94	123.92	190.31	6.93
Cocoanut meal digested, . . .	109.13	5.37	26.93	–	61.77	14.42
Per cent. digested, ...	78.34	63.63	89.59	–	84.59	102.41

Sheep VI.

Amount consumed as above, . .	728.84	50.47	88.13	195.92	365.80	28.52
263.11 grams manure excreted, . .	246.67	30.78	27.68	71.04	110.29	6.88
Grams digested, ...	482.17	19.69	60.45	124.88	255.51	21.64
Minus hay digested, ...	365.52	14.29	31.94	123.92	190.31	6.93
Cocoanut meal digested, . . .	116.65	5.40	28.51	.96	65.20	14.71
Per cent. digested, ...	83.74	63.98	94.84	7.01	89.29	104.47
Average per cent. for both sheep, .	81.04	63.81	92.22	–	86.94	103.44

Average nutritive ratio of rations for both sheep, 1:7.1.

English Hay, Period VIII.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	725.36	48.82	75.22	218.91	361.52	20.89
279.28 grams manure excreted,	259.56	25.62	26.73	73.61	122.91	10.69
Grams digested,	465.80	23.20	48.49	145.30	238.61	10.20
Per cent. digested,	64.22	47.52	64.46	66.37	66.00	48.83

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	725.36	48.82	75.22	218.91	361.52	20.89
269.70 grams manure excreted,	250.90	27.30	26.42	69.27	115.94	11.97
Grams digested,	474.46	21.52	48.80	149.64	245.58	8.92
Per cent. digested,	65.41	44.08	64.88	68.36	67.93	42.70
Average per cent. for both sheep,	64.82	45.80	64.67	67.37	66.97	45.77

Average nutritive ratio of rations for both sheep, 1:8.4.

Cocoa Shells, Period IX.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed,	579.80	33.05	57.40	176.83	295.88	16.64
150 grams cocoa shells fed,	143.21	12.65	20.84	18.98	83.38	7.36
Amount consumed,	723.01	45.70	78.24	195.81	379.26	24.00
287.64 grams manure excreted,	265.15	28.85	40.01	69.47	117.86	8.96
Grams digested,	457.86	16.85	38.23	126.34	261.40	15.04
Minus hay digested,	376.87	15.20	37.31	118.48	198.24	7.65
Cocoa shells digested,	80.99	1.65	.92	7.86	63.16	7.39
Per cent. digested,	56.55	13.04	4.41	41.41	75.75	100.41

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	723.01	45.70	78.24	195.81	379.26	24.00
284.01 grams manure excreted,	262.37	28.70	37.07	65.96	121.69	8.95
Grams digested,	460.64	17.00	41.17	129.85	257.57	15.05
Minus hay digested,	376.87	15.20	37.31	118.48	198.24	7.65
Cocoa shells digested,	83.77	1.80	3.86	11.37	59.33	7.40
Per cent. digested,	58.49	14.23	18.52	59.91	71.16	100.54
Average per cent. for both sheep,	57.52	13.64	11.47	50.66	73.46	100.48

Average nutritive ratio of rations for both sheep, 1:10.6.

Wheat Screenings, Period X.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	536.82	29.31	50.46	168.29	272.55	16.21
200 grams wheat screenings fed,	177.04	7.58	30.98	14.68	114.47	9.33
Amount consumed,	713.86	36.89	81.44	182.97	387.02	25.54
268.48 grams manure excreted,	249.98	26.20	29.35	71.17	113.36	9.90
Grams digested,	463.88	10.69	52.09	111.80	273.66	15.64
Minus hay digested,	348.93	13.48	32.80	112.75	182.61	7.46
Wheat screenings digested,	114.95	-	19.29	-	91.05	8.18
Per cent. digested,	64.93	-	62.26	-	79.54	87.67

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	713.86	36.89	81.44	182.97	387.02	25.54
260.94 grams manure excreted,	243.51	27.32	29.12	69.50	108.12	9.45
Grams digested,	470.35	9.57	52.32	113.47	278.90	16.09
Minus hay digested,	348.93	13.48	32.80	112.75	182.61	7.46
Wheat screenings digested,	121.42	-	19.52	-	96.29	8.63
Per cent. digested,	68.58	-	63.01	-	84.12	92.50
Average per cent. for both sheep,	66.76	-	62.64	-	81.83	90.09

Average nutritive ratio of rations for both sheep, 1:8.1.

3. SERIES XVIII.

Digestion Coefficients of Basal Ration used in this Series.

	English Hay. Sheep I. and II.	English Hay. Sheep V. and VI.	English Hay and Corn Meal. Periods X. and XII. Sheep I. and II.
Dry matter,	65	65	70
Ash,	31	46	43
Protein,	61	65	63
Fiber,	70	67	71
Nitrogen-free extract,	67	67	74
Fat,	53	46	59

Composition of Feedstuffs (Per Cent).

[Dry Matter.]

Period.	FEEDSTUFFS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	4.90	9.75	31.46	50.95	2.94
II.	English hay, ...	5.78	9.56	31.48	50.45	2.73
II.	Corn meal, ...	1.39	10.74	2.77	80.07	5.03
VIII.	Brook Farm hay, . . .	6.46	8.27	33.89	49.31	2.07
VIII.	Waste Sheep I., ...	4.68	4.56	38.09	51.61	1.06
VIII.	Waste Sheep II.,. . . .	6.09	7.28	33.46	51.48	1.69
IX.	English hay, ...	6.53	9.35	32.10	49.13	2.89
IX.	CXX Feed, Postum Cereal refuse.	2.74	19.57	18.11	56.46	3.12
X.	English hay, ...	6.41	9.80	31.84	49.31	2.64
X.	Corn meal, ...	1.46	10.93	2.60	80.15	4.86
X.	Gloucester fish meal, . . .	24.01	73.17	–	–	2.82
XI.	English hay, ...	6.72	9.72	31.65	49.32	2.59
XI.	Molassine meal, ...	9.40	10.81	7.54	71.72	.53
XII.	English hay, ...	6.49	9.62	31.64	49.51	2.74
XII.	Corn meal, ...	1.50	10.78	2.72	80.15	4.85
XII.	Wilcox fish guano, . . .	16.90	55.46	–	–	7.72
XIII.	English hay, ...	6.40	8.80	32.45	49.53	2.82
XIII.	Mellen's Food refuse, . . .	4.38	13.51	18.24	59.64	4.23
XIV.	English hay, ...	6.47	8.90	31.89	49.95	2.79
XIV.	Molassine meal, ...	9.47	12.49	7.79	69.65	.60
XIV.	Waste Sheep I., ...	13.60	11.33	16.54	57.08	1.45
XIV.	Brook Farm hay, . . .	6.32	8.90	32.12	50.53	2.13

Composition of Feces (Per Cent).

[Dry Matter.]

Sheep I.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	9.73	11.37	26.53	48.35	4.02
II.	Corn meal, ...	9.33	12.47	25.89	48.16	4.15
VIII.	Brook Farm hay, . . .	9.04	11.62	26.31	49.73	3.30
X.	Gloucester fish meal, . . .	15.30	17.46	21.67	42.17	3.40
XII.	Wilcox fish guano, . . .	14.34	14.74	23.29	44.29	3.34
XIV.	Molassine meal, ...	11.48	13.22	24.80	47.32	3.18

Composition of Feces (Per Cent.) — Concluded.

[Dry Matter.]

Sheep II.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	9.83	10.60	27.48	48.08	4.01
II.	Corn meal, ...	10.12	11.68	26.73	47.08	4.39
VIII.	Brook Farm hay, . . .	8.57	9.87	28.59	49.88	3.09
X.	Gloucester fish meal, . . .	16.92	18.35	20.29	40.71	3.73
XII.	Wilcox fish guano, . . .	15.36	16.41	21.36	43.30	3.57

Sheep V.

IX.	CXX Feed, Postum Cereal refuse.	8.38	17.47	28.78	42.22	3.15
XI.	Molassine meal, ...	8.76	12.64	26.74	48.06	3.80
XIII.	Mellen's Food refuse, . . .	10.32	10.99	27.60	47.81	3.28
XIV.	Brook Farm hay, . . .	9.64	10.21	30.07	47.02	3.06

Sheep VI.

IX.	CXX Feed, Postum Cereal refuse.	8.36	16.76	29.35	42.54	2.99
XI.	Molassine meal, ...	9.03	12.54	26.70	48.13	3.60
XIII.	Mellen's Food refuse, . . .	10.54	11.69	25.81	48.84	3.12

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep I.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
I.	88.62	-	-	-	-	-	-	-	-	92.50
II.	88.32	86.55	-	-	-	-	-	-	-	93.02
VIII.	-	-	88.97	-	-	-	-	-	90.12	95.52
X.	90.75	88.36	-	94.28	-	-	-	-	-	93.52
XII.	89.25	87.57	-	-	91.62	-	-	-	-	93.09
XIV.	89.60	-	-	-	-	80.81	-	-	74.76	92.20

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.) — Concluded.

Sheep II.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
I.	88.62	-	-	-	-	-	-	-	-	92.75
II.	88.32	86.55	-	-	-	-	-	-	-	93.31
VIII.	-	-	88.97	-	-	-	-	-	90.12	95.45
X.	90.75	88.36	-	94.28	-	-	-	-	-	93.32
XII.	89.25	87.57	-	-	91.62	-	-	-	-	93.18

Sheep V.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
IX.	90.07	-	-	-	-	-	90.82	-	-	93.63
XI.	89.82	-	-	-	-	81.94	-	-	-	94.08
XIII.	90 00	-	-	-	-	-	-	93.02	-	94.18
XIV.	-	-	89.85	-	-	-	-	-	-	92.93

Sheep VI.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
IX.	90.07	-	-	-	-	-	90.82	-	-	93.71
XI.	89.82	-	-	-	-	81.94	-	-	-	94.04
XIII.	90.00	-	-	-	-	-	-	93.02	-	93.99

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep I.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay, ...	648	25.83	2,586
II.	Corn meal, ...	426	21.02	1,660
VIII.	Brook Farm hay, ...	781	25.46	2,235
X.	Gloucester fish meal, ...	658	27.16	3,860
XII.	Wilcox fish guano, ...	538	24.41	2,965
XIV.	Molassine meal, ...	712	26.55	2,926

Sheep II.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay, ...	584	27.05	2,413
II.	Corn meal, ...	497	22.79	2,126
VIII.	Brook Farm hay, ...	789	27.96	2,668
X.	Gloucester fish meal, ...	537	24.33	3,596
XII.	Wilcox fish guano, ...	694	25.02	3,248

Average Daily Amount of Manure excreted and Water drunk (Grams) — Concluded.

Sheep V.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	CXX Feed, Postum Cereal refuse, . .	827	31.68	1,696
XI.	Molassine meal, ...	549	24.20	1,848
XIII.	Mellen's Food refuse, ...	778	29.72	2,238
XIV.	Brook Farm hay, ...	752	30.95	3,051

Sheep VI.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	CXX Feed, Postum Cereal refuse, . .	772	33.02	2,915
XI.	Molassine meal, ...	684	26.88	3,351
XIII.	Mellen's Food refuse, ...	946	31.26	3,801

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay, ...	143.00	143.00	145.50	144.75
II.	Corn meal, ...	140.00	139.50	140.75	141.00
VIII.	Brook Farm hay, ...	134.50	135.00	136.25	136.00
X.	Gloucester fish meal, ...	131.50	134.50	136.00	136.00
XII.	Wilcox fish guano, ...	138.75	138.25	140.25	140.25
XIV.	Molassine meal, ...	136.00	135.00	135.75	135.25

Sheep II.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay, ...	142.50	142.50	141.50	141.50
II.	Corn meal, ...	137.75	137.50	136.00	136.00
VIII.	Brook Farm hay, ...	135.75	136.00	135.25	135.00
X.	Gloucester fish meal, ...	135.25	135.75	137.00	137.50
XII.	Wilcox fish guano, ...	139.00	139.00	138.25	139.00

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds) — Concluded.

Sheep V.

Period.	CHARACTER OF FOOD OR RATION.	BEGINNING.		END.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
IX.	CXX Feed, Postum Cereal refuse, . .	166.25	166.50	163.00	163.00
XI.	Molassine meal, ...	160.25	160.25	157.50	157.75
XIII.	Mellen's Food refuse, ...	168.50	168.50	158.50	158.75
XIV.	Brook Farm hay, ...	156.75	156.00	160.75	157.75

Sheep VI.

IX.	CXX feed, Postum Cereal refuse, . .	158.25	159.25	157.25	156.25
XI.	Molassine meal, ...	154.00	154.00	155.75	154.75
XIII.	Mellen's Food refuse, ...	155.00	155.00	154.75	153.75

English Hay, Period I.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, . .	708.96	34.74	69.12	223.04	361.22	20.84
258.27 grams manure excreted, . .	238.90	23 24	27.16	63.38	115.52	9.60
Grams digested, ...	470.06	11.50	41.96	159.66	245.70	11.24
Per cent. digested, ...	66.30	33.10	60.42	71.58	68.02	53.93

Sheep II.

800 grams English hay fed, . .	708.96	34.74	69.12	223.04	361.22	20.84
270.48 grams manure excreted, . .	250.87	24.66	26.59	68.94	120.62	10.06
Grams digested, ...	458.09	10.08	42.53	154.10	240.60	10.78
Per cent. digested, ...	64.61	29.02	61.53	69.09	66.61	51.73
Average per cent. for both sheep, .	65.46	31.06	60.98	70.34	67.32	52.83

Average nutritive ratio of rations for both sheep, 1:10.0.

English Hay, Corn Meal, Period II.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed,	574.08	33.18	54.88	180.72	289.63	15.67
125 grams corn meal fed,	108.19	1.50	11.62	3.00	86.63	5.44
Amount consumed,	682.27	34.68	66.50	183.72	376.26	21.11
210.20 grams manure excreted,	195.53	18.24	24.38	50.62	94.18	8.11
Grams digested,	486.74	16.44	42.12	133.10	282.08	13.00
Per cent. digested,	71.34	47.40	63.34	72.45	74.97	61.58

Sheep II.

Amount consumed as above,	682.27	34.68	66.50	183.72	376.26	21.11
227.87 grams manure excreted,	212.63	21.52	24.84	56.83	100.11	9.33
Grams digested,	469.64	13.16	41.66	126.89	276.15	11.78
Per cent. digested,	68.83	37.95	62.65	69.07	73.39	55.80
Average per cent. for both sheep,	70.09	42.68	63.00	70.76	74.18	58.69

Average nutritive ratio of rations for both sheep, 1:11.6.

Brook Farm Hay, Period VIII.

Sheep I.

800 grams Brook Farm hay fed,	711.76	45.98	58.86	241.22	350.97	14.73
87.43 grams waste,	78.79	3.69	3.59	30.01	40.66	.84
Amount consumed,	632.97	42.29	55.27	211.21	310.31	13.89
254.57 grams manure excreted,	242.40	21.91	28.17	63.78	120.54	8.00
Brook Farm hay digested,	390.57	20.38	27.10	147.43	189.77	5.89
Per cent. digested,	61.70	48.19	49.03	69.80	61.15	42.40

Sheep II.

800 grams Brook Farm hay fed,	711.76	45.98	58.86	241.22	350.97	14.73
77.14 grams waste,	69.55	4.24	5.06	23.27	35.80	1.18
Amount consumed,	642.21	41.74	53.80	217.95	315.17	13.55
279.58 grams manure excreted,	266.86	22.87	26.34	76.30	133.10	8.25
Brook Farm hay digested,	375.35	18.87	27.46	141.65	182.07	5.30
Per cent. digested,	58.45	45.21	51.04	64.99	57.77	39.11
Average per cent. for both sheep,	60.08	46.70	50.04	67.40	59.96	40.76

Average nutritive ratio of rations for both sheep, 1:12.5.

CXX Feed, Postum Cereal Refuse, Period IX.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, . .	495.39	32.35	46.32	159.02	243.38	14.32
250 grams CXX Feed fed, ...	227.05	6.22	44.43	41.12	128.20	7.08
Amount consumed, ...	722.44	38.57	90.75	200.14	371.58	21.40
316.80 grams manure excreted, . .	296.62	24.86	51.82	85.37	125.23	9.34
Grams digested, ...	425.82	13.71	38.93	114.77	246.35	12.06
Minus hay digested, ...	322.00	14.88	30.11	106.54	163.06	6.59
CXX Feed digested, ...	103.82	–	8.82	8.23	83.29	5.47
Per cent. digested, ...	45.73	–	19.85	20.01	64.97	77.26

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	722.44	38.57	90.75	200.14	371.58	21.40
330.20 grams manure excreted, . .	309.43	25.87	51.86	90.82	131.63	9.25
Grams digested, ...	413.01	12.70	38.89	109.32	239.95	12.15
Minus hay digested, ...	322.00	14.88	30.11	106.54	163.06	6.59
CXX Feed digested, ...	91.01	–	8.78	2.78	76.89	5.56
Per cent. digested, ...	40.08	–	19.76	6.76	59.98	78.53
Average per cent. for both sheep, .	42.91	–	19.81	13.39	62.48	77.90

Average nutritive ratio of rations for both sheep, 1:9.8.

Gloucester Fish Meal, Period X.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed, . .	589.88	37.81	57.81	187.82	290.87	15.57
125 grams corn meal fed, . . .	110.45	1.61	12.07	2.87	88.53	5.37
100 grams Gloucester fish meal fed, .	94.28	22.64	68.98	–	–	2.66
Amount consumed, ...	794.61	62.06	138.86	190.69	379.40	23.60
271.60 grams manure excreted, . .	254.00	38.86	44.35	55.04	107.11	8.64
Grams digested, ...	540.61	23.20	94.51	135.65	272.29	14.96
Minus hay and corn meal digested, .	490.23	16.95	44.02	135.39	280.76	12.35
Gloucester fish meal digested, . .	50.38	6.25	50.49	.26	–	2.61
Per cent. digested, ...	53.44	27.61	73.20	–	–	98.12

Gloucester Fish Meal, Period X — Concluded.

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	794.61	62.06	138.86	190.69	379.40	23.60
243.33 grams manure excreted,	227.08	38.42	41.67	46.07	92.45	8.47
Grams digested,	567.53	23.64	97.19	144.62	286.95	15.13
Minus hay and corn meal digested,	490.23	16.95	44.02	135.39	280.76	12.35
Gloucester fish meal digested,	77.30	6.69	53.17	9.23	6.19	2.78
Per cent. digested,	81.99	29.55	77.08	–	–	104.51
Average per cent. for both sheep,	67.72	28.58	75.14	–	–	101.32

Average nutritive ratio of rations for both sheep, 1:5.2.

Molassine Meal, Period XI.

Sheep V.

550 grams English hay fed,	494.01	33.20	48.02	156.35	243.65	12.79
200 grams Molassine meal fed,	163.88	15.40	17.72	12.36	117.53	.87
Amount consumed,	657.89	48.60	65.74	168.71	361.18	13.66
241.96 grams manure excreted,	227.64	19.94	28.77	60.87	109.41	8.65
Grams digested,	430.25	28.66	36.97	107.84	251.77	5.01
Minus hay digested,	321.11	15.27	31.21	104.75	163.25	5.88
Molassine meal digested,	109.14	13.39	5.76	3.09	88.52	–
Per cent. digested,	66.60	86.95	32.51	25.00	75.32	–

Sheep VI.

600 grams English hay fed,	538.92	36.22	52.38	170.57	265.79	13.96
200 grams Molassine meal fed,	163.88	15.40	17.72	12.36	117.53	.87
Amount consumed,	702.80	51.62	70.10	182.93	383.32	14.83
268.78 grams manure excreted,	252.76	22.82	31.70	67.49	121.65	9.10
Grams digested,	450.04	28.80	38.40	115.44	261.67	5.73
Minus hay digested,	350.30	16.66	34.05	142.82	178.08	6.42
Molassine meal digested,	99.74	12.14	4.35	–	83.59	–
Per cent. digested,	60.86	78.83	24.55	–	71.12	–
Average per cent. for both sheep,	63.73	82.89	28.53	–	73.22	–

Average nutritive ratio of rations for both sheep, 1:9.4.

Wilcox Fish Guano, Period XII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed, . .	580.13	37.65	55.81	183.55	287.22	15.90
125 grams corn meal fed, . . .	109.46	1.64	11.80	2.98	87.73	5.31
100 grams Wilcox fish guano fed, .	91.62	17.36	57.42	–	–	9.30
Amount consumed, ...	781.21	56.65	125.03	186.53	374.95	30.51
244.11 grams manure excreted, . .	227.24	32.59	33.50	52.92	100.64	7.59
Grams digested, ...	553.97	24.06	91.53	133.61	274.31	22.92
Minus hay and corn meal digested, .	482.71	16.89	42.59	132.44	277.46	12.51
Fish guano digested, ...	71.26	7.17	48.94	1.17	–	10.41
Per cent. digested, ...	77.78	41.30	85.23	–	–	111.96

Sheep II.

Amount consumed as above, . .	781.21	56.65	125.03	186.53	374.95	30.51
250.16 grams manure excreted, . .	233.10	35.80	38.25	49.79	100.94	8.32
Grams digested, ...	548.11	20.85	86.78	136.74	274.01	22.19
Minus hay and corn meal digested, .	482.71	16.89	42.59	132.44	277.46	12.51
Fish guano digested, ...	65.40	3.96	44.19	4.30	–	9.68
Per cent. digested, ...	71.38	22.81	76.96	–	–	104.09
Average per cent. for both sheep, .	74.58	32.06	81.10	–	–	108.03

Average nutritive ratio of rations for both sheep, 1:5.15.

Mellen's Food Refuse, Period XIII.

Sheep V.

550 grams English hay fed, . .	495.00	31.68	43.56	160.63	245.17	13.96
250 grams Mellen's Food refuse fed, .	232.55	10.19	31.42	42.42	138.68	9.84
Amount consumed, ...	727.55	41.87	74.98	203.05	383.85	23.80
297.21 grams manure excreted, . .	279.91	28.89	30.76	77.26	133.82	9.18
Grams digested, ...	447.64	12.98	44.22	125.89	250.03	14.62
Minus hay digested, ...	321.75	14.57	28.31	107.62	164.26	6.42
Grams Mellen's Food refuse digested, .	125.89	–	15.91	18.17	85.77	8.20
Per cent. digested, ...	54.13	–	50.64	42.83	61.85	83.33

Mellen's Food Refuse, Period XIII — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	727.55	41.87	74.98	203.05	383.85	23.80
312.56 grams manure excreted, . .	293.78	30.96	34.34	75.82	143.49	9.17
Grams digested, ...	433.77	10.91	40.64	127.23	240.36	14.63
Minus hay digested, ...	321.75	14.57	28.31	107.62	164.26	6.42
Grams Mellen's Food refuse digested,	112.02	–	12.33	19.61	76.10	8.21
Per cent. digested, ...	48.17	–	39.24	46.23	54.87	83.43
Average per cent. for both sheep, .	51.15	–	44.94	44.53	58.36	83.38

Average nutritive ratio of rations for both sheep, 1:9.52.

Molassine Meal, Period XIV.

Sheep I.

600 grams English hay fed, . .	537.60	34.78	47.85	171.44	268.53	15.00
200 grams Molassine meal fed, . .	161.62	15.31	20.19	12.59	112.56	.97
Amount fed, ...	699.22	50.09	68.04	184.03	381.09	15.97
11.95 grams waste, ...	8.93	1.21	1.01	1.48	5.10	.13
Amount consumed, ...	690.29	48.88	67.03	182.55	375.99	15.84
265.45 grams manure excreted, . .	244.74	28.10	32.35	60.70	115.81	7.78
Grams digested, ...	445.55	20.78	34.68	121.85	260.18	8.06
Minus hay digested, ...	349.44	10.78	29.19	120.01	179.92	7.95
Molassine meal digested, . . .	96.11	10.00	5.49	1.84	80.26	.11
Per cent. digested, ...	59.47	65.31	27.19	14.61	71.30	11.34

Average nutritive ratio of ration, 1:11.5.

Brook Farm Hay, Period XIV.

Sheep V.

750 grams Brook Farm hay fed, . .	669.38	42.30	59.57	215.00	318.25	14.26
309.50 grams manure excreted, . .	287.62	27.73	29.37	86.49	135.23	8.80
Grams digested, ...	381.76	14.57	30.20	128.51	183.02	5.46
Per cent. digested, ...	57.03	34.44	50.70	59.77	57.51	38.29

Average nutritive ratio of ration, 1:10.7.

4. SERIES XIX.

Digestion Coefficients of Basal Ration used in this Series.

	English Hay.	English Hay and Gluten Feed.
Dry matter,	65	66
Ash,	46	31
Protein,	65	68
Fiber,	67	66
Nitrogen-free extract,	67	70
Fat,	46	56

Composition of Feedstuffs (Per Cent.).

[Dry Matter.]

Period.	FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	6.19	10.01	30.58	50.63	2.59
I.	Gluten feed,	1.10	27.75	8.78	58.00	4.37
I.	Molassine meal,	8.63	11.29	11.09	68.26	.73
II.	English hay,	5.83	9.52	31.40	50.98	2 27
II.	Gluten feed,	1.05	27.84	8.75	57.78	4.58

Composition of Feces (Per Cent.).

[Dry Matter.]

Sheep V.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	Molassine meal,	8.82	12.68	28.90	46.58	3.02
II.	English hay and gluten feed,	9.25	12.79	27.62	46.75	3.59

Sheep VI.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	Molassine meal,	8.65	12.57	27.34	48.27	3.17
II.	English hay and gluten feed,	10.47	12.62	26.49	46.81	3.61

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep V.

PERIOD.	English Hay.	Gluten Feed.	Molassine Meal.	Feces.
I.,	86.45	89.78	83.41	90.92
II.,	88.02	89.55	-	92.47

Sheep VI.

PERIOD.	English Hay.	Gluten Feed.	Molassine Meal.	Feces.
I.,	86.45	89.78	83.41	90.88
II.,	88.02	89.55	-	92.59

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep V.

Period.	CHARACTER OF FOOD OR RATION.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Molassine meal,	676	30.43	2,771
II.	English hay and gluten feed,	470	22.65	2,589

Sheep VI.

Period.	CHARACTER OF FOOD OR RATION.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Molassine meal,	627	29.35	1,899
II.	English hay and gluten feed,	465	22.30	1,183

Weights of Animals for Two Days at Beginning and Two Days at End of Period (Pounds).

Sheep V.

Period.	CHARACTER OF FOOD OR RATION.	BEGINNING.		END.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	Molassine meal,	133.25	131.75	131.50	132.25
II.	English hay and gluten feed,	132.75	131.50	129.75	130.00

Sheep VI.

Period.	CHARACTER OF FOOD OR RATION.	BEGINNING.		END.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	Molassine meal,	156.75	157.50	159.50	-
II.	English hay and gluten feed,	157.25	158.50	155.25	152.75

Molassine Meal, Period I.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, . .	475.48	29.43	47.60	145.40	240.74	12.31
150 grams gluten feed fed, . .	134.67	1.48	37.37	11.82	78.11	5.89
200 grams Molassine meal fed, . .	166.82	14.40	18.83	18.50	113.87	1.22
Amount consumed, ...	776.97	45.31	103.80	175.72	432.72	19.42
304.25 grams manure excreted, . .	276.62	24.40	35.08	79.94	128.85	8.35
Grams digested, ...	500.35	20.91	68.72	95.78	303.87	11.07
Minus English hay and gluten feed digested.	402.70	9.58	57.78	103.77	223.20	10.19
Molassine meal digested, . . .	97.65	11.33	10.94	–	80.67	.88
Per cent. digested, ...	58.54	78.47	58.10	–	70.84	72.13

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	776.97	45.31	103.80	175.72	432.72	19.42
293.54 grams manure excreted, . .	266.77	23.08	33.53	72.93	128.77	8.46
Grams digested, ...	510.20	22.23	70.27	102.79	303.95	10.96
Minus English hay and gluten feed digested.	402.70	9.58	57.78	103.77	223.20	10.19
Molassine meal digested, . . .	107.50	12.65	12.49	–	80.75	.77
Per cent. digested, ...	64.44	87.85	66.33	–	70.91	63.11
Average per cent. for both sheep, .	61.49	83.16	62.22	–	70.88	67.62

Average nutritive ratio of rations for both sheep, 1:6.15.

English Hay, Gluten Feed, Period II.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, . .	484.11	28.22	46.09	152.01	246.80	10.99
150 grams gluten feed fed, . . .	134.33	1.41	37.40	11.75	77.62	6.15
Amount consumed, ...	618.44	29.63	83.49	163.76	324.42	17.14
226.53 grams manure excreted, . .	209.47	19.38	26.79	57.86	97.92	7.52
Grams digested, ...	408.97	10.25	56.70	105.90	226.50	9.62
Per cent. digested, ...	66.13	34.59	67.91	64.67	69.82	56.13

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	618.44	29.63	83.49	163.76	324.42	17.14
223.00 grams manure excreted, . .	206.48	21.62	26.06	54.70	96.65	7.45
Grams digested , ...	411.96	8.01	57.43	109.06	227.77	9.69
Per cent. digested, ...	66.61	27.03	68.79	66.60	70.21	56.53
Average per cent. for both sheep, .	66.37	30.81	68.35	65.64	70.02	56.33

Average nutritive ratio of rations for both sheep, 1:6.23.

5. Discussion of Results.

Owing to the fact that a number of the tests were repeated in a series following, the coefficients secured for each feed in the several series are brought together and discussed below.

English Hay.

But two different lots of hay were used in all of these experiments. It consisted of mixed grasses with June grass (*Poa pratensis*) predominating; cut while in blossom, well cured and in good condition. Before feeding it was cut fine by running it through a feed cutter, and thoroughly mixed to insure uniformity through the entire lot.

Summary of Coefficients, English Hay, Series XVI., Period I.; Series XVII., Periods I. and VIII.; Series XVIII., Period I.

Lot.	Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	I.,	1	1	62.92	32.24	54.53	69.00	65.85	54.06
	II.,	1	1	59.36	27.27	52.79	62.91	63.51	54.68
	V.,	1	1	61.39	31.98	53.98	66.67	64.62	48.25
	VI.,	1	1	63.03	35.61	56.42	68.98	65.50	47.48
	Average,	1	4	61.68	31.78	54.43	66.89	64.87	51.12
II.	I.,	1	1	66.30	33.10	60.42	71.58	68.02	53.93
	II.,	1	1	64.61	29.02	61.53	69.09	66.61	51.73
	V.,	1	1	64.22	47.52	64.46	66.37	66.00	48.83
	VI.,	1	1	65.41	44.08	64.88	68.36	67.93	42.70
	Average,	1	4	65.14	38.43	62.82	68.85	67.14	49.30
	Average of all trials of similar hay for comparison.	21	73	61.00	47.00	57.00	62.00	62.00	50.00

The first lot of hay was somewhat less digestible than was the second lot, probably due to the stage of growth at time of cutting. The digestion coefficients compare quite closely with those obtained in previous experiments with similar hay.

Dried Beet Pulp and Molasses Dried Beet Pulp.

Both of these products are the dried residue from the manufacture of sugar from the sugar beet. Molasses dried beet pulp differs from the plain dried beet pulp in containing a considerable proportion of the residual molasses, probably about 25 per cent. The first-named product is noticeably darker in color.

Summary of Coefficients, Dried Beet Pulp, Series XVI., Period III.; Series XVII., Period V.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	76.72	32.56	49.97	83.56	90.00	-
II.,	1	1	71.45	18.59	55.47	67.03	86.84	-
III.,	1	1	75.56	-	50.14	99.76	73.59	-
Average,	1	3	74.58	-	51.86	83.45	83.48	-

Summary of Coefficients, Molasses Dried Beet Pulp, Series XVI., Period II.; Series XVII., Period V.

I.,	1	1	84.64	55.96	59.87	88.63	91.02	-
II.,	1	1	79.57	36.01	50.19	77.77	89.23	-
IV.,	1	1	82.80	61.06	73.53	64.56	91.37	-
Average,	1	3	82.34	51.01	61.20	76.99	90.54	-

The digestibility of the molasses pulp was about 8 per cent. higher than that of the plain pulp, due to the molasses which is, in all probability, entirely digestible. While beet pulp contains 15 to 18 per cent. of fiber, its digestibility is much higher than that of wheat bran or ground oats, due to its soft, unlignified character. For Sheep III. in the experiment with plain beet pulp, the fiber digestibility is very high, with a corresponding depression in the digestibility of the nitrogen-free extract. It is believed that this condition is abnormal, and that the average of the coefficients for Sheep I. and II. would be more accurate. The digestibility of the ash in the plain pulp is uncertain, due, partly at least, to the small amount present. There being only about ½ per cent. of ether extract (fat) in beet pulp, it is not possible to secure digestion coefficients for that ingredient. From the variations noted in the digestibility of the different ingredients it is evident that the several sheep differed in their ability to make use of the different nutrients.

Cocoanut Meal.

This product is the residue from the manufacture of cocoanut oil, and is used largely in European countries. It contains about 20 per cent. of protein and 8 to 10 per cent. of fat and some 9 to 10 per cent. of fiber. The sample used was purchased from the Edible Oils Company of New York.

Summary of Coefficients, Cocoanut Meal, Series XVII., Periods II. and VII.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	78.34	63.63	89.59	-	84.59	102.41
VI.,	1	2	83.74	64.24	89.92	23.36	88.56	102.91
Average,	1	3	81.94	64.04	89.81	-	87.24	102.74
European results,[1]	3	5	80.00[2]	-	78.00	63.00	83.00	97.00

[1] Kellner's tabulation.

[2] Organic matter.

This material shows a somewhat higher digestibility than the average of European trials, due partly to its less fiber content.

The digestibility of the fiber varied to such an extent as to warrant the elimination of the fiber coefficient, Sheep V. showing a slightly negative result, and the two trials with Sheep VI. showing 7.01 and 39.71 per cent., respectively. It seems probable that the addition of the cocoanut meal to the hay improved the digestibility of the hay fiber, which accounts for the apparently negative or variable fiber coefficients of the cocoanut meal. The ash, protein, extract matter and fat all show a high digestibility, and indicate this material to be a valuable protein concentrate.

Cottonseed Feed Meal, Creamo Brand.

This product consists of a mixture of high-grade cottonseed meal and cottonseed hull bran, the latter being the cottonseed hull from which the lint has been removed.

Summary of Coefficients, Cottonseed Feed Meal, Creamo Brand, Series XVII., Period III.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.	1	1	59.30	47.20	73.57	32.31	61.35	102.97
VI.,	1	1	57.15	51.53	76.34	19.88	61.04	98 25
Average,	1	2	58.23	49.37	74.96	26.10	61.20	100.66
High-grade cottonseed meal for comparison.	4	12	79.00	84.00	84.00	35.00	78.00	94.00

The digestion coefficients in this experiment agreed closely except for fiber. The fiber coefficient was, however, low in both instances, as was to be expected because of the tough, woody character of the hull. This material contains only about three-fourths of the total digestible dry matter of cottonseed meal of good quality. Furthermore, since it contains much less digestible protein, and two and one-half times as much total fiber as genuine cottonseed meal, it is not worth more than one-half as much for animal feeding. In fact, the northern farmer cannot afford to purchase it at present prices in place of the genuine article.

Wheat Screenings.

Wheat screenings consist of the light wheat seed, weed seeds, chaff and dirt separated from the grain as it comes to the mill in preparing the wheat for the manufacture of flour. Their composition depends upon the kind of seeds predominating and upon the amount of dirt and chaff present. They necessarily vary so much in composition that no general statement as to their nutritive value can be made, and the figures reported below should not be understood as applying to all wheat screenings. The two lots used in the present experiments were quite similar in appearance and chemical composition, and were free from an excessive amount of straw and chaff. In the first sample the following seeds and ingredients were identified: light oats, oat hulls, wheat, wheat refuse, smutted grain, yellow foxtail, green foxtail, corn cockle, bindweed, flax, lady's-thumb, charlock, wild mustard, rape, lamb's-quarters, large smartweed, chaff of various sorts, wild sunflower, pigweed, timothy, shepherd's-purse, chess, oat grass, wild oats, rye and corn, together with a few unidentified seeds. Screenings are found in the eastern markets principally as an ingredient of molasses feeds. Both lots were coarsely ground before feeding.

Summary of Coefficients, Wheat Screenings, Series XVII., Period IV. (Lot I.).

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	57.57	27.36	78.88	–	63.76	86.18
VI.,	1	1	60.65	26.10	82.97	–	65.33	87.41
Average,	1	2	59.11	26.73	80.93	–	64.55	86.80

Summary of Coefficients, Wheat Screenings, Series XVII., Period X. (Lot II.).

V.,	1	1	64.93	–	62.26	–	79.54	87.67
VI.,	1	1	68.58	–	63.01	–	84.12	92.50
Average,	1	2	66.76	–	62.64	–	81.83	90.09
Average for both trials,	2	4	62.94	–	71.79	–	73.19	88.45

The difference shown in the digestibility of the two lots can probably be accounted for by the fact that the first lot contained more fiber and less nitrogen-free extract than did the second. In both trials the fiber coefficient showed that slightly less fiber was digested than when the hay was fed alone, indicating somewhat of a depressing effect of the wheat screenings upon fiber digestibility, and also that the fiber contained in the screenings was of decidedly inferior character. The screenings contain a high ash content, but the small amount digested shows it to be of comparatively little value.

The experiment indicates that screenings, when finely ground and reasonably free from dirt, chaff and noxious seeds, possess considerable nutritive value. It is likely to be found primarily in the protein and extract matter of the screenings.

Flax Shives.

Flax shives, sometimes incorrectly called flax bran, consists of the ground refuse stalks and pods of the flax plant. It is found on the market as a component of some molasses and stock feeds.

Summary of Coefficients, Flax Shives, Series XVII., Period VI.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	42.94	21.86	79.98	22.00	41.27	92.26
VI.,	1	1	47.82	23.69	82.08	29.58	45.63	93.09
Average,	1	2	45.38	22.78	81.03	25.79	43.45	92.68

This experiment showed flax shives to have a digestibility of about 45 per cent. as compared with 66 per cent. for wheat bran. It contained nearly 35 per cent. of fiber of which about one-fourth proved digestible, and must be pronounced as distinctly inferior for feeding.

Cocoa Shells.

Cocoa shells are the hard, outside coating or bran of the cocoa bean. Up to the present time they have been used but little as a feedstuff, although their chemical composition would indicate that they have considerable feeding value. Preliminary feeding experiments have shown them to be rather unpalatable.

Summary of Coefficients, Cocoa Shells, Series XVII., Period IX.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	56.55	13.04	4.41	41.41	75.75	100.44
II.,	1	1	58.59	14.32	18.52	59.91	71.16	100.54
Average,	1	2	57.52	13.64	11.47	50.66	73.46	100.48

The coefficients for both sheep agree closely except for protein. In both cases, however, the protein coefficient is extremely low, due, perhaps, to the presence of considerable vegetable alkaloid. It is doubtful if they have more than one-half the value of corn meal. Their use will be more fully discussed elsewhere.

Brook Farm Hay.

This hay was purchased at the Brook Farm, just north of the station grounds, and consisted of a mixture of timothy, red top and clover in good condition. Sheep I. and II. left a considerable portion, Sheep I. refusing the finer portion and Sheep II. the coarser part. In a later trial Sheep V. was induced to eat the entire ration. It was used in connection with a feeding experiment.

Summary of Coefficients, Brook Farm Hay, Series XVIII., Periods VIII. and XIV.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	61.70	48.19	49.03	69.80	61.15	42.40
II.,	1	1	58.45	45.21	51.40	64.99	57.77	39.11
V.,	1	1	57.03	34.44	50.70	59.77	57.51	38.29
Average,	1	3	59.06	42.61	50.38	64.85	58.81	39.93
Average all trials, mixed hay for comparison.	5	10	55.00	30.00	47.00	65.00	59.00	45.00

The experiment shows this particular lot of hay to compare favorably with all previous trials of mixed hay composed of similar grasses.

CXX Feed.

This feed is a product from the Postum Cereal Company's works, and is probably the residue from the manufacture of Instant Postum, prepared by roasting a mixture of wheat, wheat bran and molasses.

Summary of Coefficients, CXX Feed, Series XVIII., Period IX.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	45.73	-	19.85	20.00	64.97	77.26
VI.,	1	1	40.08	-	19.76	6.76	59.98	78.53
Average,	1	2	42.91	-	19.81	13.39	62.48	77.90

The results of the experiment show the CXX Feed to have a very low digestibility, probably due to the roasting that the product undergoes. The protein and fiber appear to be of little nutritive value, and the material as a whole must be pronounced quite inferior for feeding purposes.

Fish Meals.

Two varieties of fish meal were used in these experiments. The first, Gloucester fish meal, was received from the Russia Cement Company, and is a by-product from the manufacture of fish glue. The second is a by-product from the menhaden fisheries, and up to the present time has been used almost entirely as a fertilizer. It had not been treated with sulphuric acid. The fish guano contained more fat and less ash and protein than did the Gloucester fish meal. In some European countries dried fish and even the raw refuse is used as a food for domestic animals.

Summary of Coefficients, Gloucester Fish Meal, Series XVIII., Period X.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	53.44	27.61	73.20	-	-	98.12
II.,	1	1	81.99	29.55	77.08	-	-	104.51
Average,	1	2	67.72	28.58	75.14	-	-	101.32

Summary of Coefficients, Wilcox Fish Guano, Series XVIII., Period XII.

I.,	1	1	77.78	41.30	85.23	-	-	111.96
II.,	1	1	71.38	22.81	76.96	-	-	104.09
Average,	1	2	74.58	32.06	81.10	-	-	108.03

The nutritive ratio of the basal ration of hay and corn meal was as 1:10. It would have been better had the basal ration consisted of hay and some nitrogenous concentrate with a ratio of 1:7 or thereabouts, for it is well known that a highly nitrogenous concentrate added to a basal ration with a wide nutritive ratio (1:8 or above) has a tendency to improve the digestibility of the fiber and extract matter of the latter, and would indicate an apparent increase in the digestibility of the fish.

Gloucester Fish Meal. — In case of Sheep I.,[1] the addition of the fish to the basal ration did not appear to improve the digestibility of the carbohydrates, although it may have had a favorable effect upon the protein of the basal ration. In case of Sheep II. it exerted a noticeably favorable effect upon both the fiber and extract, and perhaps upon the protein of the basal ration.

Wilcox Fish Guano. — Sheep II. did not digest as much of the bone (ash) as did Sheep I. The fish seemed to exert a slightly favorable effect upon the fiber, but an adverse effect upon the extract matter. The addition of the fish did improve the digestibility of the fat in the basal ration.

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[1] The coefficients with this sheep were not satisfactory.

It is intended to repeat these experiments, using a basal ration with a narrower ratio.

The two samples of fish were composed of approximately 20 per cent. ash, from 60 to 70 per cent. protein, and 3 and 10 per cent. fat, respectively. Its chief value, from a nutritive standpoint, consists in the amount of digestible protein and fat. In view of the prices usually prevailing for fish, it is doubtful if it would prove particularly economical as a food for animals in place of nitrogenous concentrates of vegetable origin.

Molassine Meal.

This is an English product now being extensively sold in Massachusetts. It is composed of from 25 to 30 per cent. of sphagnum moss and from 70 to 75 per cent. of cane or beet molasses. The moss, according to the manufacturers, comes from the upper layers of large bogs in Yorkshire, Eng. Such material, as time passes, decays and forms peat. A sample of the dried sphagnum moss was found to analyze as follows: —

	Per Cent.
Water,	11.45
Protein,	2.72
Fat,	1.18
Nitrogen-free extract,	43.82
Fiber,	39.74
Ash,	1.09

It is doubtful if the moss has any particular nutritive properties;[1] hence, the nutritive value of the feed consists in the amount of molasses present. The larger part of the crude protein found in Molassine meal exists in the form of amids.

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[1] Kellner and Pfeiffer have shown that peat is without nutritive value.

Summary of Coefficients, Molassine Meal, Series XVIII., Periods XI. and XIV.; Series XIX., Period I.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,[1]	1	1	59.47	65.31	27.19	14.61	71.30	11.34
V.,[2]	1	1	58.54	78.47	58.10	–	70.84	72.13
V.,[1]	1	1	66.60	86.95	32.51	25.00	75.32	–
VI.,[2]	1	1	64.44	87.85	66.33	–	70.91	63.11
VI.,[1]	1	1	60.86	78.83	24.55	–	71.12	–
Average,	1	5	61.98	79.48	41.74	–	71.90	–

[1] Fed with English hay. [2] Fed with English hay and gluten feed.

In three trials the basal ration was English hay; in two other trials English hay and gluten feed were used. Inasmuch as it contains practically no fat, and that its nitrogen is in the amido form, its chief nutritive value is to be found in the carbohydrates. On the basis of the digestibility and at the same moisture content, Molassine meal would have scarcely two-thirds of the nutritive value of corn meal.[1]

Mellen's Food Refuse.

This material is sold to a limited extent in Massachusetts and consists of the residue resulting from the manufacture of an infant food. The original ingredients used in the food are barley, malt, flour and bran.

Summary of Coefficients, Mellen's Food Refuse, Series XVIII., Period XIII.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	54.13	–	50.64	42.83	61.85	83.33
VI.,	1	1	48.17	–	39.24	46.23	54.87	83.43
Average,	1	2	51.15	–	44.94	44.53	58.36	83.38

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[1] See also Bulletin 146, p. 58.

Mellen's Food refuse shows a total digestibility only of about 51 per cent., which is lower than would be obtained for any of the ingredients used in the manufacture of the food. This is due, no doubt, to the fact that the more digestible parts are to be found in the food itself.

Complete Summary of All Coefficients (Per Cent.).

Food.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
English hay, Series XVI. and part of Series XVII.	I.,	62.92	32.24	54.53	69.00	65.85	54.06
	II.,	59.36	27.27	52.79	62.91	63.51	54.68
	V.,	61.39	31.98	53.98	66.67	64.62	48.25
	VI.,	63.03	35.61	56.42	68.98	65.50	47.48
Average,	.	61.68	31.78	54.43	66.89	64.87	51.12
English hay, part of Series XVII., Series XVIII. and XIX.	I.,	66.30	33.10	60.42	71.58	68.02	53.93
	II.,	64.61	29.02	61.53	69.09	66.61	51.73
	V.,	64.22	47.52	64.46	66.37	66.00	48.83
	VI.,	65.41	44.08	64.88	68.36	67.93	42.70
Average,	.	65.14	38.43	62.82	68.85	67.14	49.30
Dried beet pulp,	I.,	76.72	32.56	49.97	83.56	90.00	-
	II.,	71.45	18.59	55.47	67.03	86.84	-
	III.,	75.56	-	50.14	99.76	73.59	-
Average,	.	74.58	25.58	51.86	83.45	83.48	-
Molasses dried beet pulp,	I.,	84.64	55.96	59.87	88.63	91.02	-
	II.,	79.57	36.01	50.19	77.77	89.23	-
	IV.,	82.80	61.06	73.53	64.56	91.37	-
Average,	.	82.34	51.01	61.20	76.99	90.54	-
Cocoanut meal,	V.,	78.34	63.63	89.59	-	84.59	102.41
	VI.,	83.74	63.98	94.84	7.01	89.29	104.47
	VI.,	83.74	64.50	85.00	39.71	87.83	101.35
Average,	.	81.94	64.04	89.81	23.36	87.24	102.74
Cottonseed feed meal, Creamo brand,	V.,	59.30	47.20	74.28	32.31	61.35	102.97
	VI.,	57.15	51.53	76.34	19.88	61.04	98.25
Average,	.	58.23	49.37	75.31	26.10	61.20	100.61
Wheat screenings,	V.,	57.57	27.36	78.88	-	63.76	86.18
	VI.,	60.65	26.10	82.97	-	65.33	87.41
Average,	.	59.11	26.73	80.93	-	64.55	86.80
Wheat screenings,	V.,	64.93	-	62.26	-	79.54	87.67
	VI.,	68.58	-	63.01	-	84.12	92.50
Average,	.	66.76	-	62.64	-	81.83	90.09

Complete Summary of All Coefficients (Per Cent.) — Concluded.

Food.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Flax shives,	V.,	42.94	21.86	79.98	22.00	41.27	92.26
	VI.,	47.82	23.69	82.08	29.58	45.63	93.09
Average,	.	45.38	22.78	81.03	25.79	43.45	92.68
Cocoa shells,	I.,	56.55	13.04	4.41	41.41	75.75	100.41
	II.,	58.49	14.23	18.52	59.91	71.16	100.54
Average,	.	57.52	13.64	11.47	50.66	73.46	100.48
English hay and corn meal (5½ to 1),[1]	I.,	71.34	47.40	63.34	72.45	74.97	61.58
	II.,	68.83	37.95	62.65	69.07	73.39	55.80
Average,	.	70.09	42.68	63.00	70.76	74.18	58.69
Brook Farm hay,	I.,	61.70	48.19	49.03	69.80	61.15	42.40
	II.,	58.45	45.21	51.40	64.99	57.77	39.11
	V.,	57.03	34.44	50.70	59.77	57.51	38.29
Average,	.	59.06	42.61	50.38	64.85	58.81	39.93
CXX Feed, Postum Cereal refuse,	V.,	45.73	-	19.85	20.01	64.97	77.26
	VI.,	40.08	-	19.76	6.76	59.98	78.53
Average,	.	42.91	-	19.81	13.39	62.48	77.90
Gloucester fish meal,	I.,	53.44	27.61	73.20	-	-	98.12
	II.,	81.99	29.55	77.08	-	-	104.51
Average,	.	67.72	28.58	75.14	-	-	101.32
Wilcox fish guano,	I.,	77.78	41.30	85.23	-	-	111.96
	II.,	71.38	22.81	76.96	-	-	104.09
Average,	.	74.58	32.06	81.10	-	-	108.03
Molassine meal,	I.,	59.47	65.31	27.19	14.61	71.30	11.34
	V.,	58.54	78.47	58.10	-	70.84	72.13
	V.,	66.60	86.95	32.51	25.00	75.32	-
	VI.,	64.44	87.85	66.33	-	70.91	63.11
	VI.,	60.86	78.83	24.55	-	71.12	-
Average,	.	61.98	79.48	41.74	-	71.90	-
Mellen's Food refuse,	V.,	54.13	-	50.64	42.83	61.85	83.33
	VI.,	48.17	-	39.24	46.23	54.87	83.43
Average,	.	51.15	-	44.94	44.53	58.36	83.38
English hay and gluten feed (550 to 150 grams).	V.,	66.13	34.59	67.91	64.67	69.82	56.13
	VI.,	66.61	27.03	68.79	66.60	70.21	56.53
Average,	.	66.37	30.81	68.35	65.64	70.02	56.33

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[1] Parts by weight.

A SUMMARY OF METEOROLOGICAL RECORDS.

Location and Equipment.

The meteorological observatory is located in the tower at the southeast corner of South College, at an elevation of about 50 feet above the ground. It was equipped with a number of Draper self-recording instruments, and the records date from Jan. 1, 1889. The location is on a gravel ridge with an open exposure to the north, west and southwest, with slightly higher ground about a mile to the south and a ridge considerably higher about half a mile to the east.

The top of the tower is 72 feet above the ground, and the exposure is good in all directions. The anemometer, anemoscope, wind-pressure instrument and electrical sunshine recorder are mounted from 3 to 5 feet above the top of the tower, and the recording apparatus is in the room below. The thermometer shelter and rain gauges are on the campus about 300 feet southwest from the tower and on slightly lower ground.

The observatory is in latitude 42° 23′ 48.5″ N., longitude 72° 31′ 10″ W., and the base of the tower is 223 feet above mean low water, Boston harbor, as determined by levels connecting with those of the Boston & Maine Railroad. The standard barometer is of United States Weather Bureau pattern, reading to 1/500 of an inch, and the cistern is 273½ feet above sea level. The Draper self-recording barometer is mounted 1 foot higher.

The sunshine recorder of the Draper pattern was replaced by an electrical one from Friez in 1906, and the Draper anemometer by one of United States Weather Bureau pattern at about the same time. These records are received on a triple register, which also records the rainfall. The rain gauges are about 2 feet above ground and 218 feet above sea level. A United States Weather Bureau gauge is used in determining the precipitation, and the tipping bucket electrical recording gauge in determining the time and rate.

The Draper self-registering thermometer, Weather Bureau pattern, maximum and minimum thermometers and hygrometer are in a standard shelter about 4 feet above ground and 220 feet above sea level.

On Jan. 1, 1904, the time of making observations was changed from 7 A.M., 2 P.M. and 9 P.M. to 8 A.M. and 8 P.M., so as to conform with the practice of the United States Weather Bureau. This change should be noted in comparing the dew point and relative humidity before and after that date. Other data are probably not affected by the change.

Mean Barometer.

[Readings are reduced to freezing and sea level.]

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean Annual.
1889, . .	30.11	30.24	29.84	29.80	29.92	29.96	29.91	30.01	30.00	30.05	30.04	30.14	30.00
1890, . .	30.19	30.10	29.99	30.10	29.96	29.98	30.02	30.00	30.12	29.88	30.01	30.01	30.03
1891, . .	29.96	30.04	30.10	29.92	29.98	29.92	29.99	29.96	30.11	30.03	30.12	30.08	30.02
1892, . .	29.96	30.11	29.90	29.97	29.94	29.92	29.99	30.02	30.10	29.90	29.99	30.01	29.98
1893, . .	29.95	30.11	30.06	30.09	29.90	30.06	29.97	30.00	30.06	30.13	30.12	30.12	30.05
1894, . .	30.18	30.16	30.09	30.05	30.00	30.00	30.01	30.03	30.14	30.02	30.08	30.15	30.08
1895, . .	30.05	29.92	30.00	30.12	30.10	30.17	30.03	30.02	30.10	30.08	30.19	30.15	30.08
1896, . .	30.16	29.86	29.99	30.14	29.98	29.95	29.97	29.99	30.00	30.01	30.14	30.14	30.03
1897, . .	30.04	30.06	30.04	30.04	29.92	29.90	29.94	29.94	30.09	30.12	30.03	30.04	30.01
1898, . .	29.98	30.05	30.20	29.93	29.94	29.95	30.02	29.96	30.01	30.09	30.01	29.96	30.01
1899, . .	30.11	29.98	29.94	30.04	30.00	29.98	29.93	29.98	30.02	30.19	30.01	30.03	30.02
1900, . .	30.03	29.97	29.95	29.96	29.91	29.91	29.91	29.99	30.04	30.15	29.99	30.03	29.98
1901, . .	29.95	29.79	29.90	29.97	29.88	29.95	29.93	30.02	30.03	30.08	29.93	30.03	29.96
1902, . .	30.04	29.78	29.91	29.88	29.84	29.84	29.96	29.92	30.04	30.03	30.06	30.06	29.95
1903, . .	29.91	29.98	30.20	29.87	29.94	29.94	29.88	30.00	30.10	30.00	30.01	29.97	30.00
1904, . .	30.08	30.11	30.11	29.97	30.02	30.02	29.98	30.03	30.08	30.08	29.95	30.02	30.03
1905, . .	30.08	30.12	30.12	29.85	29.93	29.93	29.95	29.98	30.05	30.10	30.01	30.08	29.94
1906, . .	30.09	30.20	30.09	29.98	29.94	29.94	29.98	30.02	30.09	30.09	30.04	30.12	30.05
1907, . .	30.23	30.09	30.08	29.88	29.93	29.93	29.87	30.00	30.02	30.05	30.05	30.02	30.02
1908, . .	29.97	30.08	30.10	29.92	30.03	30.03	30.04	30.03	30.10	30.17	30.01	30.04	30.04
1909, . .	30.15	29.96	29.82	30.06	29.94	29.97	29.91	30.02	30.11	30.03	30.16	29.89	30.01
1910, . .	30.11	30.07	30.08	29.97	29.96	29.92	29.89	30.07	30.10	30.01	29.80	30.03	30.00
1911, . .	30.12	30.12	29.99	30.14	30.03	29.94	29.99	30.02	30.06	30.11	30.01	30.15	30.06
1912, . .	30.02	29.93	30.13	29.99	29.96	29.99	29.98	29.95	30.07	30.06	30.00	30.01	30.01
1913, . .	30.10	30.01	30.11	30.02	29.99	30.00	29.94	30.03	30.13	29.97	30.13	30.01	30.04
Mean, .	30.06	30.03	30.03	29.99	29.96	29.96	29.96	30.00	30.07	30.06	30.04	30.05	30.01

Range of Barometer (in Inches).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Range Annual.
1889, . .	1.62	1.51	1.58	1.16	.75	.97	.68	.66	.98	.96	1.31	1.75	1.81
1890, . .	1.50	1.35	1.08	1.08	.81	.58	.63	1.10	.69	1.09	.98	1.20	1.76
1891, . .	1.93	1.36	1.21	1.42	.79	.53	.74	.61	.73	1.11	1.56	1.22	2.05
1892, . .	1.38	1.65	1.16	1.02	.96	.84	.97	.55	.96	.98	1.00	1.01	1.65
1893, . .	1.53	1.83	1.27	1.25	1.16	.67	.68	.93	.81	1.37	1.16	1.53	1.92
1894, . .	1.89	1.65	1.04	.86	.93	.75	.57	.44	1.11	1.19	1.22	1.23	2.01
1895, . .	1.46	1.88	1.24	1.40	.84	.66	.51	.53	.68	1.09	1.47	1.78	2.27
1896, . .	.97	1.77	1.52	.96	.75	.83	.79	.59	.85	1.10	1.23	1.57	2.22
1897, . .	1.57	1.15	1.74	1.10	.76	.55	.72	.61	.73	1.12	1.48	1.42	1.76
1898, . .	1.43	1.63	1.17	.86	.76	.95	.81	.60	.82	1.19	1.25	1.39	1.75
1899, . .	1.70	1.41	1.54	.90	.60	.59	.51	.56	.88	.76	1.10	1.58	1.82
1900, . .	1.58	1.89	1.52	1.01	.99	.67	.73	.53	1.03	1.07	1.71	1.53	1.89
1901, . .	1.68	.97	1.17	1.19	.77	.61	.59	.51	1.00	1.22	1.14	1.13	1.68
1902, . .	1.49	1.41	1.55	1.04	.94	1.27	.58	.67	.78	1.25	1.12	1.34	1.89
1903, . .	1.49	1.55	1.19	1.15	.85	.97	.57	.77	.78	1.08	1.32	1.56	1.77
1904, . .	1.50	1.36	1.58	1.00	.75	.81	.73	.73	1.20	1.23	1.84	1.43	2.23
1905, . .	1.37	1.28	.89	1.15	.85	.83	.58	.72	.66	1.16	1.22	1.53	1.64
1906, . .	1.53	1.28	1.64	1.05	1.08	.77	.90	.72	1.03	1.41	1.05	1.30	1.70
1907, . .	1.34	1.27	1.39	1.42	.67	.71	.76	.71	.91	1.24	1.59	1.46	1.79
1908, . .	1.73	1.89	1.22	1.35	1.11	.65	.66	.68	.73	1.17	1.14	1.31	1.97
1909, . .	1.64	1.63	1.52	1.14	0.82	.68	.88	.97	.80	.97	1.24	1.54	1.91
1910, . .	1.76	1.40	1.11	.90	1.02	.83	.57	.82	.57	1.05	1.02	1.44	1.76
1911, . .	1.50	1.09	1.77	1.14	.97	.69	.74	.76	.85	1.04	1.24	1.20	1.77
1912, . .	1.60	1.75	1.43	1.32	.86	.64	.89	.77	.75	.87	1.17	1.46	1.98
1913, . .	2.18	.88	1.92	1.06	.87	.80	.65	.72	.83	1.38	1.65	1.34	2.33
Mean, .	1.57	1.47	1.38	1.12	.87	.75	.70	.69	.87	1.12	1.29	1.41	1.89

Maximum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	30.82	30.97	30.66	30.54	30.40	30.54	30.35	30.45	30.40	30.52	30.67	30.96	30.97
1890, . .	30.94	30.72	30.56	30.57	30.32	30.28	30.27	30.28	30.42	30.41	30.35	30.61	30.94
1891, . .	30.62	30.69	30.57	30.56	30.44	30.22	30.37	30.27	30.45	30.67	30.74	30.55	30.74
1892, . .	30.67	30.72	30.45	30.53	30.43	30.39	30.50	30.24	30.42	30.43	30.44	30.53	30.72
1893, . .	30.61	30.83	30.63	30.65	30.32	30.36	30.25	30.30	30.45	30.65	30.70	30.92	30.92
1894, . .	30.77	30.89	30.57	30.52	30.50	30.33	30.31	30.24	30.63	30.42	30.73	30.53	30.89
1895, . .	30.61	30.44	30.52	30.70	30.55	30.51	30.33	30.29	30.41	30.67	30.73	30.83	30.83
1896, . .	30.56	30.49	30.62	30.60	30.48	30.42	30.49	30.39	30.40	30.62	30.86	30.94	30.94
1897, . .	30.77	30.70	30.88	30.61	30.36	30.28	30.33	30.18	30.40	30.67	30.60	30.60	30.88
1898, . .	30.61	30.64	30.76	30.34	30.33	30.35	30.44	30.26	30.41	30.46	30.53	30.52	30.76
1899, . .	30.92	30.53	30.49	30.39	30.29	30.25	30.24	30.31	30.47	30.50	30.54	30.66	30.92
1900, . .	30.67	30.75	30.59	30.48	30.38	30.19	30.16	30.25	30.35	30.52	30.64	30.51	30.75
1901, . .	30.69	30.34	30.43	30.52	30.20	30.24	30.29	30.28	30.51	30.66	30.37	30.58	30.69
1902, . .	30.66	30.27	30.50	30.28	30.43	30.46	30.29	30.26	30.38	30.52	30.48	30.75	30.75
1903, . .	30.62	30.48	30.65	30.46	30.54	30.39	30.17	30.42	30.42	30.40	30.70	30.60	30.70
1904, . .	30.90	30.67	30.96	30.50	30.37	30.35	30.26	30.42	30.62	30.57	30.57	30.54	30.96
1905, . .	30.70	30.62	30.60	30.37	30.38	30.19	30.15	30.27	30.41	30.58	30.63	30.86	30.86
1906, . .	30.78	30.95	30.92	30.45	30.49	30.35	30.46	30.38	30.50	30.63	30.42	30.77	30.95
1907, . .	30.75	30.78	30.59	30.41	30.34	30.22	30.18	30.35	30.39	30.60	30.59	30.45	30.78
1908, . .	30.59	30.83	30.59	30.52	30.31	30.40	30.26	30.34	30.45	30.59	30.45	30.61	30.83
1909, . .	30.75	30.53	30.36	30.60	30.29	30.26	30.27	30.39	30.52	30.52	30.74	30.58	30.75
1910, . .	30.87	30.80	30.50	30.40	30.40	30.24	30.18	30.37	30.34	30.47	30.40	30.78	30.87
1911, . .	30.66	30.64	30.72	30.71	30.40	30.24	30.26	30.30	30.41	30.59	30.48	30.57	30.72
1912, . .	30.59	30.47	30.70	30.62	30.31	30.31	30.35	30.29	30.37	30.46	30.50	30.61	30.70
1913, . .	30.73	30.44	30.88	30.56	30.39	30.43	30.19	30.41	30.58	30.52	30.72	30.47	30.88
Mean, .	30.71	30.65	30.62	30.52	30.39	30.33	30.29	30.32	30.44	30.55	30.58	30.65	30.83

Minimum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Minimum Annual.
1889, . .	29.20	29.46	29.08	29.38	29.65	29.57	29.67	29.79	29.42	29.56	29.36	29.21	29.08
1890, . .	29.44	29.37	29.48	29.49	29.51	29.70	29.64	29.18	29.73	29.32	29.37	29.41	29.18
1891, . .	28.69	29.33	29.36	29.14	29.65	29.69	29.63	29.66	29.72	29.56	29.18	29.33	28.69
1892, . .	29.29	29.07	29.29	29.51	29.47	29.55	29.53	29.69	29.46	29.45	29.44	29.52	29.07
1893, . .	29.08	29.00	29.36	29.40	29.16	29.69	29.57	29.37	29.64	29.28	29.54	29.39	29.00
1894, . .	28.88	29.24	29.53	29.66	29.57	29.58	29.74	29.80	29.52	29.23	29.51	29.30	28.88
1895, . .	29.17	28.56	29.28	29.30	29.71	29.85	29.82	29.76	29.73	29.58	29.26	29.05	28.56
1896, . .	29.59	28.72	29.10	29.64	29.73	29.59	29.70	29.80	29.55	29.52	29.63	29.37	28.72
1897, . .	29.20	29.55	29.14	29.51	29.60	29.63	29.61	29.57	29.67	29.55	29.12	29.18	29.12
1898, . .	29.18	29.01	29.59	29.48	29.57	29.40	29.63	29.66	29.59	29.27	29.28	29.13	29.01
1899, . .	29.22	29.12	28.95	29.49	29.69	29.66	29.63	29.75	29.56	29.74	29.44	29.10	29.10
1900, . .	29.08	28.86	29.06	29.47	29.39	29.51	29.42	29.72	29.32	29.42	28.93	28.98	28.86
1901, . .	29.01	29.37	29.26	29.33	29.43	29.63	29.70	29.76	29.51	29.44	29.23	29.42	29.01
1902, . .	29.17	28.86	28.95	29.24	29.49	29.24	29.61	29.59	29.60	29.27	29.36	29.41	28.86
1903, . .	29.13	28.93	29.46	29.31	29.69	29.42	29.60	29.65	29.69	29.32	29.38	29.04	28.93
1904, . .	29.40	29.31	29.38	29.50	29.62	29.54	29.53	29.69	29.42	29.28	28.73	29.11	28.73
1905, . .	29.33	29.34	29.71	29.22	29.53	29.36	29.57	29.55	29.75	29.42	29.41	29.33	29.22
1906, . .	29.25	29.67	29.28	29.40	29.41	29.58	29.56	29.66	29.47	29.22	29.37	29.47	29.25
1907, . .	29.41	29.51	29.29	28.99	29.69	29.51	29.42	29.64	29.48	29.36	29.00	29.05	28.99
1908, . .	28.86	28.94	29.37	29.27	29.20	29.75	29.69	29.66	29.72	29.42	29.31	29.30	28.86
1909, . .	29.11	28.90	28.84	29.46	29.47	29.58	29.39	29.42	29.72	29.55	29.50	29.04	28.84
1910, . .	29.11	29.40	29.39	29.50	29.38	29.41	29.61	29.55	29.77	29.42	29.38	29.34	29.11
1911, . .	29.16	29.55	28.95	29.57	29.43	29.55	29.52	29.54	29.56	29.55	29.24	29.37	28.95
1912, . .	28.99	28.72	29.27	29.30	29.45	29.67	29.46	29.52	29.62	29.59	29.33	29.15	28.72
1913, . .	28.55	29.56	29.26	29.50	29.52	29.63	29.54	29.69	29.75	29.14	29.07	29.13	28.55
Mean, .	29.14	29.17	29.27	29.40	29.52	29.57	29.59	29.63	29.60	29.42	29.29	29.25	28.93

Mean Hourly Temperature.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	32.9	23.9	37.9	49.3	61.4	67.7	69.5	65.5	61.9	46.5	41.9	35.0	49.5
1890, . .	32.1	31.7	31.9	46.5	57.1	65.3	69.8	67.2	59.7	48.5	38.0	22.9	47.6
1891, . .	27.6	29.6	33.7	49.4	57.3	66.6	68.2	70.2	65.3	49.9	39.7	38.3	49.7
1892, . .	25.3	28.4	33.1	48.7	56.1	70.3	72.2	70.0	60.6	50.8	39.3	28.5	48.6
1893, . .	19.0	25.7	33.4	44.7	58.7	69.0	71.4	71.0	58.1	53.9	40.1	28.2	47.8
1894, . .	28.7	25.5	41.6	47.9	58.7	69.4	73.5	69.3	64.8	52.1	36.4	28.5	49.7
1895, . .	25.0	22.3	33.0	46.9	61.3	70.5	69.3	70.4	63.8	48.1	41.1	29.0	48.4
1896, . .	23.2	30.0	29.4	49.2	62.4	65.0	70.7	68.2	59.3	46.4	41.9	25.3	49.3
1897, . .	24.2	25.1	32.9	46.5	57.1	61.8	70.5	66.0	59.8	49.9	36.9	28.8	46.6
1898, . .	21.8	26.3	39.6	43.0	55.6	66.0	70.9	69.7	63.0	51.1	37.3	26.2	47.5
1899, . .	23.3	21.8	30.6	46.1	55.7	67.4	70.1	68.0	59.7	51.1	37.0	30.8	46.8
1900, . .	25.5	24.6	29.5	46.9	55.4	67.1	70.6	70.1	63.8	54.5	41.3	30.6	48.3
1901, . .	23.7	20.1	33.1	46.8	56.2	68.0	72.5	69.9	62.1	50.1	33.4	26.4	46.9
1902, . .	22.9	25.5	40.5	47.3	57.0	63.5	67.8	66.1	60.3	50.7	42.8	23.5	47.3
1903, . .	24.3	27.3	42.6	46.9	59.2	59.6	68.9	62.0	61.3	51.1	34.3	22.5	46.7
1904, . .	14.3	17.7	31.0	42.5	60.1	65.0	69.8	66.4	59.8	47.2	33.0	19.6	43.9
1905, . .	20.4	17.7	33.1	45.6	56.9	64.4	71.1	65.8	59.1	49.9	36.3	29.8	45.8
1906, . .	29.6	23.8	28.3	45.1	56.7	66.1	70.1	70.5	64.0	50.5	38.5	24.2	47.3
1907, . .	22.4	16.5	35.2	41.5	51.8	63.9	70.0	66.1	61.3	45.6	37.6	30.5	45.2
1908, . .	25.7	20.5	34.7	45.1	59.2	67.6	72.5	66.6	62.9	51.3	38.0	27.1	47.6
1909, . .	25.7	28.1	32.4	44.4	55.5	66.4	68.7	66.5	60.5	47.7	41.3	24.7	46.8
1910, . .	25.5	23.9	39.1	50.6	56.1	63.8	72.1	67.1	61.1	51.7	36.4	21.7	47.4
1911, . .	27.4	23.3	31.5	43.7	61.9	64.5	73.7	67.8	60.2	48.5	36.7	32.7	47.6
1912, . .	14.6	20.7	30.5	45.2	58.1	65.0	71.6	66.4	61.2	52.4	40.0	32.9	46.5
1913, . .	33.6	22.7	37.9	47.6	55.6	66.4	71.4	69.5	59.7	54.7	41.6	31.3	49.3
Mean, .	24.7	24.1	34.1	46.3	57.6	66.0	70.7	67.9	61.3	50.2	38.6	28.0	47.5

Range of Temperature (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Range Annual.
1889, . .	48.0	49.0	40.0	46.0	50.0	44.0	31.0	37.0	41.0	43.0	41.0	57.5	92.0
1890, . .	57.0	54.5	69.0	57.5	48.5	47.5	54.0	47.0	52.0	52.0	51.0	48.5	100.5
1891, . .	52.5	60.0	57.5	61.5	62.0	60.0	48.5	47.5	55.5	69.0	60.5	51.5	100.0
1892, . .	66.5	53.5	54.5	58.5	56.0	54.0	52.0	44.0	49.0	54.5	53.0	47.0	104.5
1893, . .	63.0	54.5	48.0	48.5	57.0	52.5	49.5	57.0	51.0	57.0	52.0	64.0	109.0
1894, . .	52.0	66.0	56.0	63.0	56.0	55.5	50.0	54.0	56.0	43.0	55.0	55.0	115.0
1895, . .	50.0	55.0	44.0	56.0	62.5	51.0	54.0	52.0	64.0	51.0	57.0	68.0	105.0
1896, . .	53.0	67.0	52.0	67.5	62.5	51.0	41.0	55.0	57.5	49.0	54.0	62.0	111.0
1897, . .	51.0	59.0	60.5	60.0	48.0	47.5	36.0	43.0	59.5	63.5	58.0	62.5	102.5
1898, . .	65.5	73.0	45.5	54.0	46.0	50.0	56.5	46.5	58.5	59.5	56.0	60.0	115.5
1899, . .	70.5	61.0	42.0	61.0	55.5	51.0	47.0	51.0	51.5	61.5	40.5	59.0	114.5
1900, . .	56.0	64.0	46.0	59.0	67.5	54.0	51.0	53.0	53.5	61.0	55.0	57.5	104.0
1901, . .	55.0	48.5	57.0	58.5	50.5	57.5	52.0	33.5	59.0	51.0	54.0	70.5	111.0
1902, . .	47.5	49.0	48.5	57.5	61.0	49.0	45.0	44.0	51.5	51.5	47.5	64.0	106.0
1903, . .	57.5	68.0	57.0	62.0	68.0	48.5	52.5	42.0	60.5	55.0	68.5	61.5	109.0
1904, . .	66.0	56.0	68.0	50.5	48.0	51.5	48.0	49.5	58.5	59.5	49.0	47.0	120.5
1905, . .	64.0	59.5	76.0	57.0	50.5	54.0	47.0	47.5	53.0	59.0	50.0	51.5	106.0
1906, . .	56.5	57.5	60.5	53.5	58.5	50.5	43.5	43.0	59.5	53.5	43.5	48.5	98.5
1907, . .	78.0	61.5	74.0	49.0	65.0	57.0	46.0	55.0	49.0	52.5	40.5	50.5	119.5
1908, . .	58.5	68.0	62.0	66.0	55.0	55.5	50.5	51.5	55.0	67.5	39.5	63.5	108.0
1909, . .	61.0	57.5	41.0	61.0	49.0	51.5	51.0	56.0	48.0	61.0	53.5	60.0	102.5
1910, . .	65.0	60.5	65.5	56.0	53.0	53.0	48.5	44.5	48.0	65.0	46.0	49.0	106.0
1911, . .	49.0	54.5	56.5	68.0	67.5	45.0	55.0	50.0	55.0	48.5	48.0	52.0	107.0
1912, . .	64.0	66.0	59.5	54.0	55.5	55.0	57.5	50.0	51.0	56.5	48.5	62.0	117.5
1913, . .	48.5	59.5	73.0	62.0	58.5	55.0	59.0	56.0	56.5	54.5	45.0	48.0	104.5
Mean, .	58.2	59.3	56.5	57.9	56.5	52.0	49.0	48.4	54.1	56.0	50.7	56.8	107.6

Maximum Temperatures (in Degrees F.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	56.0	47.0	61.0	78.0	88.0	90.0	85.0	82.0	81.0	69.0	61.0	63.0	90.0
1890, . .	61.5	57.5	62.5	79.5	80.0	88.0	94.0	88.5	80.5	78.0	62.5	43.5	94.0
1891, . .	52.0	54.0	56.5	79.5	87.0	94.0	90.0	92.5	91.5	89.0	64.0	60.5	94.0
1892, . .	57.0	46.5	60.5	78.5	84.0	95.0	94.0	94.0	80.0	77.5	67.0	46.0	95.0
1893, . .	50.0	50.0	52.0	67.5	87.0	94.0	90.5	96.0	81.0	80.0	63.0	52.0	96.0
1894, . .	53.0	49.0	73.0	79.0	85.0	93.0	98.0	91.0	91.0	75.0	65.0	51.0	98.0
1895, . .	45.5	45.0	49.0	81.0	92.0	95.0	90.0	90.0	97.0	71.0	72.0	65.0	97.0
1896, . .	41.0	53.0	57.0	88.5	94.5	90.0	91.0	97.0	88.5	72.0	69.0	52.5	97.0
1897, . .	51.0	48.0	59.0	80.5	79.5	85.5	91.0	85.0	91.5	84.0	63.0	59.0	91.5
1898, . .	50.0	54.0	60.0	71.0	78.5	89.5	96.5	91.0	93.0	86.5	62.0	48.0	96.5
1899, . .	49.0	51.0	52.0	82.0	88.5	93.0	90.0	92.0	84.0	82.0	58.0	61.0	93.0
1900, . .	51.5	56.0	49.0	80.8	91.5	94.0	95.5	96.0	89.0	83.0	67.0	58.0	96.0
1901, . .	47.0	44.0	56.5	86.5	82.0	98.5	100.5	86.5	92.0	75.0	60.0	60.0	100.5
1902, . .	47.0	54.0	65.0	83.0	91.0	89.0	90.0	87.0	86.5	74.0	65.0	49.0	91.0
1903, . .	45.5	57.0	76.0	84.0	92.5	86.5	97.0	84.5	91.0	77.5	74.5	52.0	97.0
1904, . .	40.0	48.0	65.0	70.5	85.0	92.5	94.5	89.5	84.5	77.5	56.5	43.5	94.5
1905, . .	51.0	48.5	77.0	79.0	82.5	90.0	93.0	89.0	85.0	80.5	61.0	54.5	93.0
1906, . .	60.0	52.5	53.0	74.5	90.0	87.5	88.5	90.5	91.0	77.5	62.0	45.5	91.0
1907, . .	54.5	43.0	79.5	70.5	90.0	95.0	90.0	96.0	85.0	73.0	60.0	60.5	96.0
1908, . .	53.0	56.0	67.0	84.0	88.5	91.5	96.0	88.5	88.0	90.5	58.0	65.5	96.0
1909, . .	54.0	54.5	54.0	80.0	81.5	91.5	93.0	94.0	83.0	85.0	72.0	51.5	94.0
1910, . .	56.0	53.5	78.0	80.0	84.0	88.0	97.0	85.5	82.0	84.0	61.0	47.0	97.0
1911, . .	50.5	51.5	59.0	86.0	94.5	89.5	104.0	94.5	84.0	72.5	66.5	62.0	104.0
1912, . .	45.0	49.5	60.5	78.0	88.0	91.0	98.5	89.0	86.0	83.0	67.0	65.0	98.5
1913, . .	59.5	55.0	74.0	84.5	89.0	92.0	100.0	97.0	87.5	79.0	68.0	53.0	100.0
Mean,	51.2	51.1	62.2	79.4	87.0	91.3	93.7	90.7	86.9	79.0	64.2	54.7	95.6

Minimum Temperatures (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Minimum Annual.
1889, . .	8.0	—2.0	21.0	32.0	38.0	46.0	34.0	45.0	40.0	26.0	20.0	5.5	—2.0
1890, . .	4.5	3.0	—6.5	22.0	31.5	40.5	40.0	41.5	28.5	26.0	11.5	—5.0	—6.5
1891, . .	—0.4	—6.0	—1.0	18.0	25.0	34.0	41.5	45.0	36.0	20.0	3.5	9.0	—6.0
1892, . .	—9.5	—7.0	6.0	20.5	28.0	41.0	42.0	50.0	31.0	23.0	14.0	—1.0	—9.5
1893, . .	—13.0	—4.5	4.0	19.0	30.0	41.5	41.0	39.0	30.0	23.0	11.0	—12.0	—13.0
1894, . .	1.0	—17.0	17.0	16.0	29.0	37.5	48.0	37.0	35.0	32.0	10.0	—4.0	—17.0
1895, . .	—4.5	—10.0	5.0	25.0	29.5	44.0	46.0	38.0	33.0	20.0	15.0	—3.0	—10.0
1896, . .	—12.0	—14.0	5.0	21.0	32.0	39.0	50.0	42.0	31.0	23.0	15.0	—9.5	—14.0
1897, . .	0.0	—11.0	—1.5	20.5	31.5	38.0	55.0	42.0	32.0	20.5	5.0	—3.5	—11.0
1898, . .	—15.5	—19.0	14.5	17.0	32.5	39.5	40.0	44.5	34.5	27.0	6.0	—12.0	—19.0
1899, . .	—21.5	—10.0	10.0	21.0	33.0	42.0	43.0	41.0	32.5	20.5	17.5	2.0	—21.5
1900, . .	—4.5	—8.0	3.0	21.0	24.0	40.0	44.5	43.0	35.5	22.0	12.0	0.5	—8.0
1901, . .	—8.0	—4.5	—0.5	28.0	31.5	41.0	48.5	53.0	33.0	24.0	6.0	—10.5	—10.5
1902, . .	—0.5	5.0	16.5	25.5	30.0	40.0	45.0	43.0	35.0	22.5	17.5	—15.0	—15.0
1903, . .	—12.0	—11.0	19.0	22.0	24.5	38.0	44.5	42.5	30.5	22.5	6.0	—9.5	—12.0
1904, . .	—26.0	—8.0	—3.0	20.0	37.0	44.0	46.5	40.0	26.0	18.0	7.5	—3.5	—26.0
1905, . .	—13.0	—11.0	1.0	22.0	32.0	36.0	46.0	41.5	32.0	21.5	11.0	3.0	—13.0
1906, . .	3.5	—5.0	—7.5	21.0	31.5	37.0	45.0	47.5	31.5	24.0	18.5	—3.0	—7.5
1907, . .	—23.5	—18.5	5.5	20.5	25.0	38.0	44.0	41.0	36.0	20.5	19.5	10.0	—23.5
1908, . .	—5.5	—12.0	5.0	18.0	33.5	36.0	46.0	37.0	33.0	23.0	18.5	2.0	—12.0
1909, . .	—7.0	—3.0	13.0	19.0	32.5	40.0	42.0	38.0	35.0	24.0	18.5	—8.5	—8.5
1910, . .	—9.0	—7.0	12.5	24.0	31.0	35.0	48.5	41.0	34.0	19.0	15.0	—2.0	—9.0
1911, . .	1.5	—3.0	2.5	18.0	27.0	44.5	49.0	44.5	29.0	24.0	18.5	10.0	—3.0
1912, . .	—19.0	—16.5	1.0	24.0	32.5	36.0	41.0	39.0	35.0	26.5	18.5	3.0	—19.0
1913, . .	11.0	—4.5	1.0	22.5	30.5	37.0	41.0	41.0	31.0	24.5	23.0	5.0	—4.5
Mean, .	—7.0	—8.2	5.7	21.5	30.5	39.4	45.3	42.3	32.8	23.1	13.5	—2.9	—12.0

Mean Dew Point (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	26.3	21.2	30.4	43.8	52.8	61.1	62.7	59.5	56.9	39.4	38.3	30.9	43.6
1890, . .	23.8	25.2	26.5	35.6	58.0	57.9	61.5	57.2	55.8	41.0	29.7	14.7	40.6
1891, . .	20.7	21.7	22.6	36.3	44.6	57.0	58.5	62.4	58.1	40.6	30.4	28.2	40.1
1892, . .	18.8	20.9	21.5	33.0	44.9	62.3	60.9	62.1	51.9	41.0	32.1	20.5	39.2
1893, . .	13.9	17.3	24.0	31.4	45.7	58.3	58.8	59.9	49.1	44.2	29.9	21.9	37.9
1894, . .	21.6	17.9	31.1	34.2	52.6	57.9	62.4	58.6	56.2	44.6	27.3	22.3	40.5
1895, . .	19.2	17.1	26.2	35.8	48.7	59.6	59.3	60.4	54.8	35.4	34.4	23.6	39.5
1896, . .	14.3	22.0	25.6	35.9	48.3	53.9	62.4	61.7	54.5	42.4	37.7	19.6	39.9
1897, . .	18.0	18.1	26.9	35.7	48.0	53.3	64.6	59.7	52.7	39.0	31.8	24.2	39.6
1898, . .	18.4	21.8	30.5	34.2	48.8	59.3	64.6	64.6	56.9	46.6	32.7	20.8	41.6
1899, . .	16.6	17.0	25.5	36.5	48.6	59.5	62.5	59.4	51.5	48.8	29.8	25.1	40.1
1900, . .	18.1	17.8	19.3	34.9	43.7	57.0	62.3	62.0	54.7	47.1	32.0	21.7	39.2
1901, . .	16.6	10.6	24.7	35.6	45.7	56.2	63.4	62.3	54.5	39.9	24.1	17.9	37.6
1902, . .	12.3	15.1	32.2	36.3	44.0	53.5	57.3	57.8	53.7	40.5	34.2	15.0	37.7
1903, . .	16.0	21.0	34.6	34.1	44.9	53.7	59.3	54.7	52.5	39.2	25.6	16.1	37.6
1904, . .	9.3	9.5	22.4	31.5	48.4	56.6	61.5	59.0	52.7	37.5	25.1	12.6	35.5
1905, . .	12.8	9.2	24.8	33.5	45.7	56.5	63.2	59.0	52.4	40.3	26.8	23.8	37.3
1906, . .	20.8	15.2	19.3	34.7	46.4	58.3	63.1	63.6	55.2	42.9	27.7	16.5	38.6
1907, . .	13.4	9.0	25.8	32.0	42.2	55.0	61.0	56.5	54.6	37.1	32.0	23.7	36.9
1908, . .	16.5	14.7	26.9	31.9	50.1	56.2	63.7	58.3	53.5	41.8	30.1	18.6	38.5
1909, . .	19.0	21.0	26.0	35.5	45.1	56.6	58.6	57.8	52.6	38.0	32.6	15.8	38.2
1910, . .	18.2	16.9	28.8	39.2	45.5	55.2	61.0	57.4	53.5	41.2	28.2	14.2	38.3
1911, . .	19.7	15.3	22.2	30.1	51.7	55.8	61.7	59.0	52.9	40.1	27.4	23.9	38.3
1912, . .	7.8	12.6	23.4	37.0	50.2	54.5	60.5	58.1	54.3	41.7	31.6	23.5	38.6
1913, . .	25.9	14.1	30.7	38.5	46.0	54.6	59.8	58.6	51.0	46.5	32.1	23.5	40.1
Mean, .	17.5	16.9	26.1	35.1	47.6	56.8	61.4	60.0	53.9	41.5	30.5	20.7	39.0

Mean Relative Humidity.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	79.0	90.0	75.0	78.3	73.8	79.1	78.2	80.4	83.3	75.7	75.4	75.2	78.6
1890, . .	68.2	74.8	77.3	64.7	67.1	71.3	70.1	74.9	80.9	68.2	67.8	67.2	71.1
1891, . .	72.2	69.4	63.7	60.1	59.3	65.3	66.1	70.3	72.1	65.5	68.7	68.7	66.8
1892, . .	73.7	72.8	64.1	54.5	60.3	68.9	65.6	74.9	70.7	65.5	71.0	70.3	67.7
1893, . .	80.2	74.7	71.4	64.8	66.0	71.1	64.8	70.7	72.8	67.0	68.8	80.9	71.1
1894, . .	78.8	77.5	67.5	60.5	65.8	68.1	68.2	69.9	74.4	82.7	70.8	79.0	71.9
1895, . .	82.5	83.9	80.6	68.1	65.0	68.5	72.7	72.7	73.7	69.2	80.5	75.4	74.4
1896, . .	73.3	87.5	85.3	62.0	62.5	67.3	73.1	79.9	84.0	85.0	82.3	79.8	76.9
1897, . .	77.1	75.7	78.9	68.2	71.5	73.3	80.1	79.6	76.6	68.7	83.2	83.9	76.4
1898, . .	85.2	83.1	72.6	72.1	78.4	77.1	79.3	82.1	80.0	83.6	83.4	80.2	79.8
1899, . .	77.7	82.5	79.1	69.2	70.3	74.0	75.2	74.1	74.0	75.9	76.2	79.4	75.6
1900, . .	75.1	77.4	67.8	64.7	65.5	69.5	71.1	75.9	73.1	77.0	75.9	74.9	72.3
1901, . .	74.3	68.5	70.8	68.1	68.1	65.5	72.3	76.3	76.8	70.5	71.1	69.8	71.0
1902, . .	66.2	66.8	72.3	67.1	63.4	70.8	77.2	76.3	79.1	70.9	75.6	72.5	71.6
1903, . .	72.0	77.7	76.4	64.7	61.3	81.1	71.4	78.2	75.0	74.5	73.5	76.5	73.5
1904, . .	85.5	77.7	74.4	70.8	69.7	77.0	77.7	80.5	81.8	74.0	77.5	77.8	77.0
1905, . .	77.2	75.1	76.7	66.7	68.2	78.8	79.1	82.5	83.2	75.9	73.5	80.6	76.5
1906, . .	74.8	77.4	73.9	70.3	70.9	79.1	82.4	82.9	80.1	84.1	72.2	77.0	77.1
1907, . .	76.1	80.2	73.4	74.1	75.3	76.9	76.4	74.9	83.0	77.7	85.9	80.4	77.9
1908, . .	73.8	84.8	77.9	64.3	74.8	66.2	76.6	79.0	79.1	79.0	79.6	75.1	75.8
1909, . .	78.5	78.9	81.3	76.3	71.2	73.6	71.8	78.1	83.1	76.1	77.2	75.2	76.8
1910, . .	80.9	81.3	72.8	69.1	71.6	75.4	70.3	76.3	82.7	75.0	78.7	78.4	76.0
1911, . .	78.8	77.6	73.2	65.2	72.2	74.5	70.7	77.5	82.4	79.0	73.5	77.3	75.2
1912, . .	81.3	78.4	80.3	77.2	78.5	70.0	71.5	78.3	84.0	74.9	77.2	75.4	77.3
1913, . .	79.0	74.5	79.3	74.4	73.0	68.4	70.5	74.2	80.2	79.2	74.0	81.2	75.7
Mean, .	76.9	77.9	74.6	67.8	68.9	72.4	73.3	76.8	78.6	75.0	75.7	76.5	74.6

Mean Per Cent. of Cloudiness from Tri-daily or Semi-daily Observations.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	55	40	63	55	42	53	54	43	65	60	68	61	55
1890, . .	52	66	66	50	59	50	56	57	59	64	47	53	57
1891, . .	61	59	55	49	54	47	54	58	50	54	50	51	53
1892, . .	63	55	45	42	66	50	35	53	29	46	58	45	49
1893, . .	52	57	46	55	55	58	44	45	46	40	49	54	50
1894, . .	53	53	55	53	52	54	50	44	53	44	50	44	50
1895, . .	51	39	55	54	46	48	58	44	42	42	61	45	49
1896, . .	43	63	54	39	40	47	50	40	52	63	59	42	49
1897, . .	46	51	56	46	47	47	64	42	39	39	71	68	51
1898, . .	66	64	53	68	65	57	53	60	48	62	60	66	60
1899, . .	53	58	66	42	54	54	50	57	47	60	53	52	54
1900, . .	52	62	47	46	54	49	48	49	54	64	72	62	55
1901, . .	58	45	68	75	70	48	63	67	51	48	65	65	60
1902, . .	60	63	66	68	58	62	66	50	57	51	62	60	60
1903, . .	61	53	63	50	36	71	52	63	42	58	41	49	53
1904, . .	55	42	57	52	45	59	55	47	54	42	43	57	51
1905, . .	58	31	46	43	56	61	55	56	48	36	42	56	49
1906, . .	51	44	49	49	47	54	53	50	32	52	53	66	50
1907, . .	58	41	44	33	68	50	42	36	64	30	48	51	49
1908, . .	37	42	48	42	50	28	47	45	27	37	46	49	41
1909, . .	61	60	49	52	56	44	33	35	55	49	56	45	50
1910, . .	60	57	49	56	66	59	34	47	55	44	68	55	54
1911, . .	62	55	49	42	55	54	42	61	53	59	60	63	55
1912, . .	55	36	53	64	64	43	46	50	60	40	51	58	52
1913, . .	63	42	62	55	53	35	39	41	47	63	53	45	50
Mean, .	55.4	51.1	54.6	51.2	54.3	51.3	49.7	49.6	49.2	49.9	55.4	54.5	52.2

Hours of Bright Sunshine by Sun Thermometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Possible hours,	294	296	371	402	453	457	462	429	373	341	293	283	4,454
1889, . .	134	183	138	191	270	277	182	194	120	129	84	108	2,010
1890, . .	112	131	160	245	225	264	289	199	166	129	143	131	2,194
1891, . .	126	124	195	240	226	248	222	204	224	150	141	143	2,245
1892, . .	128	138	196	244	183	218	287	201	234	178	101	144	2,261
1893, . .	130	111	172	166	188	209	259	225	185	182	133	112	2,072
1894, . .	120	121	150	174	208	180	237	237	176	160	128	159	2,051
1895, . .	153	187	172	188	243	246	192	251	254	197	111	169	2,363
1896, . .	157	168	210	258	297	263	260	254	189	115	105	172	2,448
1897, . .	144	154	188	239	236	248	214	274	221	209	90	108	2,325
1898, . .	132	138	200	168	200	270	236	201	218	157	126	113	2,159
1899, . .	151	147	134	280	221	235	259	206	200	140	130	142	2,245
1900, . .	167	120	216	227	235	259	260	226	177	136	86	108	2,216
1901, . .	117	172	93	103	159	254	208	160	215	178	100	107	1,866
1902, . .	120	138	143	139	210	179	185	209	149	164	109	119	1,864
1903, . .	114	145	138	199	311	102	247	169	236	154	182	129	2,126
1904, . .	144	173	172	182	256	256	274	292	204	183	148	115	2,401
1905, . .	119	178	216	247	286	247	263	242	186	209	156	128	2,477
1906, . .	128	183	225	269	288	316	278	266	254	189	155	111	2,660
1907, . .	130	200	245	268	209	217	297	217	110	177	125	122	2,317
1908, . .	154	200	220	277	282	362	308	268	242	186	111	133	2,743
1909, . .	127	157	232	220	263	300	290	241	192	194	146	148	2,510
1910, . .	119	180	275	286	287	279	371	229	245	229	137	156	2,793
1911, . .	145	132	236	296	320	280	297	227	195	124	74	105	2,431
1912, . .	149	180	224	198	214	314	260	238	156	163	146	148	2,390
1913, . .	179	205	182	211	221	312	324	282	182	91	113	121	2,423
Mean, .	137	159	189	221	224	253	260	228	197	165	122	130	2,304
Mean per cent., .	46.6	53.4	50.9	55.0	49.5	55.4	56.3	53.3	52.9	48.4	41.6	45.9	51.7

Precipitation (in Inches).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	3.29	1.45	1.46	2.42	4.71	5.01	10.52	2.72	3.17	4.58	6.04	3.57	48.94
1890, . .	2.61	4.20	5.37	1.73	5.39	1.53	5.63	4.88	5.85	7.13	1.32	2.86	48.50
1891, . .	6.75	4.23	2.99	2.66	1.97	4.75	5.28	4.18	2.66	2.94	2.99	5.40	46.80
1892, . .	5.85	1.90	2.40	0.76	6.28	3.46	4.41	6.47	2.16	0.66	4.98	1.01	40.34
1893, . .	3.33	5.75	3.66	4.41	5.02	3.32	2.59	3.49	2.82	4.88	2.81	4.86	46.94
1894, . .	2.16	1.74	1.77	1.83	4.00	3.13	1.55	0.31	4.63	4.85	3.14	3.53	32.64
1895, . .	3.87	1.05	2.71	5.56	2.07	2.76	3.87	3.46	5.04	4.77	5.36	3.94	44.46
1896, . .	1.07	4.67	6.11	1.32	2.58	2.57	4.96	3.84	5.41	3.23	3.03	0.87	39.66
1897, . .	3.00	2.52	3.53	2.42	4.38	6.65	14.51	4.29	1.94	0.73	5.85	7.23	57.05
1898, . .	7.15	3.80	1.63	3.73	5.61	3.69	4.09	6.85	3.65	6.27	5.48	2.30	54.25
1899, . .	2.80	3.56	7.13	1.79	1.28	4.13	4.89	2.00	7.90	1.84	2.17	2.00	41.49
1900, . .	4.08	8.12	5.76	1.85	3.78	3.65	4.67	4.11	3.67	3.72	5.87	2.40	51.68
1901, . .	1.81	0.62	5.66	5.95	6.91	0.87	3.86	6.14	4.17	3.88	2.08	7.77	49.72
1902, . .	1.72	3.54	5.29	3.31	2.32	4.54	4.66	4.65	5.83	5.59	1.27	4.27	46.99
1903, . .	3.28	4.27	6.40	2.30	0.48	7.79	4.64	4.92	1.66	2.72	2.04	3.95	44.45
1904, . .	4.74	2.45	4.48	5.73	4.55	5.35	2.62	4.09	5.45	1.74	1.35	2.75	45.30
1905, . .	3.90	1.70	3.66	2.56	1.28	2.86	2.63	6.47	6.26	2.27	2.06	3.15	38.80
1906, . .	2.18	2.73	4.90	3.25	4.95	2.82	3.45	6.42	2.59	5.69	1.98	4.49	45.45
1907, . .	2.73	1.92	1.82	1.98	4.02	2.36	3.87	1.44	8.74	5.00	4.50	3.89	42.27
1908, . .	2.25	3.53	2.86	1.97	4.35	0.76	3.28	4.27	1.73	1.57	1.06	3.05	30.68
1909, . .	3.56	5.16	3.01	5.53	3.36	2.24	2.24	3.79	4.99	1.23	1.06	2.95	39.12
1910, . .	6.14	5.08	1.37	3.07	2.67	2.65	1.90	4.03	2.86	0.93	3.69	1.72	36.11
1911, . .	2.36	2.18	3.80	1.87	1.37	2.02	4.21	5.92	3.41	8.81	3.84	4.42	44.21
1912, . .	2.18	3.16	5.70	3.92	4.34	0.77	2.61	3.22	2.52	2.07	4.03	4.04	38.56
1913, . .	3.98	2.94	6.38	3.30	4.94	0.90	1.59	2.26	2.56	5.16	2.11	3.38	39.50
Mean, .	3.47	3.28	3.99	3.01	3.74	3.22	4.34	4.17	4.07	3.69	3.20	3.59	43.76

Wind Movement (in Miles).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, .	5,101	4,828	7,068	5,648	4,056	4,056	4,032	2,811	4,310	4,762	2,589	4,445	53,706
1890, .	4,914	4,616	5,395	5,032	5,284	3,776	3,976	4,116	3,507	4,143	4,228	5,673	54,648
1891, .	4,954	4,759	6,261	5,484	4,610	3,713	3,907	3,324	3,201	4,319	5,215	5,465	55,212
1892, .	5,059	3,438	7,046	5,370	5,056	4,500	3,365	3,390	3,672	4,071	5,231	4,522	54,720
1893, .	4,056	5,242	5,757	5,384	4,833	3,572	3,640	4,126	3,508	4,198	4,179	3,916	52,411
1894, .	4,193	4,865	4,406	4,105	2,180	1,838	1,109	1,920	1,414	2,540	4,179	3,508	36,257
1895, .	2,896	3,920	4,360	4,098	4,071	3,050	2,934	3,397	3,444	4,029	4,156	5,506	46,861
1896, .	4,943	6,445	8,182	4,674	4,838	3,926	4,048	2,968	4,686	4,544	4,654	5,290	59,198
1897, .	5,501	4,493	5,363	5,523	5,603	4,208	4,007	3,452	3,506	3,938	4,558	4,068	54,220
1898, .	3,494	3,699	3,864	5,477	4,769	4,162	3,377	3,111	2,787	3,999	4,856	4,830	48,425
1899, .	4,926	4,427	5,275	3,984	4,219	3,814	3,891	2,522	3,967	2,582	3,361	4,142	47,110
1900, .	4,904	5,016	5,602	5,039	4,381	4,101	3,701	2,322	3,042	3,315	4,877	4,203	50,503
1901, .	5,224	5,484	5,482	6,211	4,525	3,647	2,763	2,144	2,358	3,652	4,583	4,280	50,353
1902, .	4,078	5,199	6,601	4,642	4,328	4,102	2,929	2,386	2,680	4,398	3,077	4,018	48,438
1903, .	4,254	4,529	4,169	5,125	3,908	3,130	3,087	2,105	2,890	4,703	3,362	4,994	46,256
1904, .	4,112	4,910	4,444	4,902	3,830	3,127	3,268	3,232	3,602	4,160	3,470	3,940	46,994
1905, .	5,180	4,503	3,006	4,855	5,004	3,108	3,464	3,030	2,527	3,397	4,317	4,051	46,442
1906, .	5,706	4,565	5,686	4,777	3,766	1,409	3,773	3,412	4,249	4,398	5,978	5,554	53,273
1907, .	4,987	5,272	5,718	7,096	5,946	4,223	4,114	3,928	3,582	5,111	4,773	5,266	60,016
1908, .	7,770	5,511	5,759	8,208	5,818	4,571	3,815	3,802	3,757	3,643	5,485	5,432	63,571
1909, .	5,991	5,585	7,034	6,679	5,371	4,225	5,097	3,485	4,008	4,400	5,793	5,845	63,513
1910, .	5,786	5,834	5,579	5,533	5,289	3,685	3,812	4,271	3,336	5,467	5,215	5,435	59,242
1911, .	6,085	5,515	7,485	5,738	4,939	3,546	3,878	3,029	3,809	3,451	5,950	4,857	58,282
1912, .	4,872	4,798	5,291	6,094	5,332	4,533	3,992	3,698	2,980	3,953	5,037	5,337	55,897
1913, .	5,359	5,194	6,413	5,659	3,672	3,746	4,315	3,441	3,220	4,698	5,003	4,400	55,120
Mean, .	4,974	4,906	5,650	5,413	4,625	3,671	3,612	3,177	3,362	4,115	4,565	4,759	52,827

Maximum Wind Pressure (in Pounds per Square Foot).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	26.0	24.0	16.7	15.5	9.0	11.5	10.0	6.5	9.7	12.2	14.5	29.0	29.0
1890, . .	27.7	17.5	13.5	11.5	16.5	10.0	9.2	13.0	5.0	11.0	9.5	24.5	27.7
1891, . .	16.2	13.5	10.5	14.0	10.7	10.5	4.5	2.5	4.0	9.5	15.7	14.0	16.2
1892, . .	10.5	11.5	20.5	16.7	15.7	20.5	11.5	7.5	15.5	12.5	16.0	13.5	20.5
1893, . .	12.0	20.0	18.5	24.5	24.7	9.0	13.0	37.5	14.5	23.0	14.0	18.5	37.5
1894, . .	20.0	22.5	11.5	15.5	14.5	14.0	9.5	9.5	13.0	10.0	18.0	15.0	22.5
1895, . .	13.0	25.0	20.0	10.0	7.0	8.0	8.0	5.5	43.0	14.0	22.0	24.0	43.0
1896, . .	15.0	24.5	19.0	18.0	25.0	7.7	8.5	12.5	19.0	12.0	15.0	12.0	25.0
1897, . .	18.5	10.0	13.5	14.0	22.0	7.0	12.0	14.0	20.0	11.5	20.0	12.0	22.0
1898, . .	22.5	15.5	15.5	10.0	18.0	8.5	17.5	13.0	30.5	12.0	19.0	28.0	30.5
1899, . .	20.0	15.0	22.0	9.5	10.5	7.5	12.0	5.5	6.5	6.5	11.0	15.5	22.0
1900, . .	20.5	30.5	16.0	13.0	22.0	12.5	23.0	16.0	17.0	10.0	18.0	13.0	30.5
1901, . .	12.5	10.5	10.5	13.5	11.5	7.5	14.5	2.0	24.0	9.0	17.5	14.5	24.0
1902, . .	12.0	24.0	24.0	14.0	10.0	15.0	7.5	8.0	4.0	8.0	9.5	12.5	24.0
1903, . .	12.5	22.0	8.0	12.5	9.5	9.0	15.5	3.0	7.5	3.0	9.5	17.0	22.0
1904, . .	11.0	23.5	14.5	15.5	11.0	6.0	11.0	6.5	14.5	23.5	11.5	9.5	23.5
1905, . .	23.5	18.0	16.5	18.0	9.5	6.0	9.0	7.0	7.0	9.0	9.0	14.0	23.5
1906, . .	8.0	8.5	7.0	10.0	7.5	5.0	6.5	4.5	4.5	9.0	8.5	12.0	12.0
1907, . .	14.0	20.0	27.0	12.0	6.5	6.0	32.5	4.5	6.0	9.0	8.5	18.5	32.5
1908, . .	16.0	23.0	10.0	32.0	13.0	7.0	10.0	4.0	9.0	9.0	9.5	7.5	32.0
1909, . .	8.5	18.5	18.0	27.5	8.0	7.0	7.0	3.0	5.5	8.5	13.0	14.0	27.5
1910, . .	15.0	15.0	11.5	6.0	7.5	4.0	6.0	8.5	2.5	8.0	7.5	10.5	15.0
1911, . .	19.0	9.5	21.0	9.0	7.5	5.0	7.5	3.0	5.0	6.0	15.0	30.5	30.5
1912, . .	19.5	23.0	6.0	10.0	13.5	8.5	5.5	6.5	3.5	5.0	18.0	10.0	23.0
1913, . .	18.0	13.5	23.5	16.5	5.5	4.5	27.0	4.5	6.5	23.0	14.5	7.0	27.0
Maximum,	27.7	30.5	27.0	32.0	25.0	20.5	32.5	37.5	43.0	23.5	22.0	30.5	43.0

Maximum Velocity of Wind (in Miles per Hour).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	72	69	58	56	42	48	45	36	44	50	54	76	76
1890, . .	74	59	52	48	57	45	43	51	32	47	44	70	74
1891, . .	57	52	46	53	46	46	30	23	28	44	56	53	57
1892, . .	46	48	64	58	56	64	48	39	56	50	57	52	64
1893, . .	49	63	61	70	70	42	51	87	54	68	53	61	87
1894, . .	63	67	48	56	54	53	44	44	51	45	60	55	67
1895, . .	51	71	63	45	37	40	40	33	93	53	66	69	93
1896, . .	55	70	62	60	71	39	41	50	62	49	55	49	71
1897, . .	61	45	52	53	66	37	49	53	63	48	63	49	66
1898, . .	67	56	56	45	60	41	59	51	78	49	62	75	78
1899, . .	64	55	66	44	46	39	49	33	36	36	47	56	66
1900, . .	64	78	57	51	66	50	68	57	60	45	60	51	78
1901, . .	49	46	46	52	48	39	54	20	69	42	59	54	69
1902, . .	49	69	69	53	45	55	39	40	28	40	44	50	69
1903, . .	50	66	40	50	44	43	56	24	39	40	44	58	66
1904, . .	47	69	54	56	47	35	47	36	54	69	48	44	69
1905, . .	69	60	57	60	44	35	43	37	37	43	43	53	69
1906, . .	45	41	37	45	39	32	36	30	30	42	41	49	49
1907, . .	53	63	74	49	36	35	81	30	35	42	41	61	81
1908, . .	56	68	45	80	51	37	45	28	42	42	44	39	80
1909, . .	41	61	60	74	40	37	37	24	33	41	51	53	74
1910, . .	55	55	48	35	39	28	35	41	22	40	39	46	55
1911, . .	62	44	65	42	39	32	39	24	32	35	55	79	79
1912, . .	62	68	35	45	52	41	33	36	26	32	60	45	68
1913, . .	60	52	68	58	33	30	73	30	36	68	54	37	73

Snow, Frost and Weather.

YEAR.	Last Snow.	First Snow.	Total Snowfall (Inches).	Last Frost.	First Frost.	Number of Days of Precipitation.	Number of Clear Days.	Number of Fair Days.	Number of Cloudy Days.
1889, . .	April 2	Oct. 13	26.0	May 26	Sept. 21	119	94	110	161
1890, . .	April 8	Oct. 19	43.5	May 12	Sept. 25	141	137	105	123
1891, . .	May 5	Nov. 26	54.2	May 19	Oct. 12	112	145	103	117
1892, . .	April 10	Nov. 5	42.5	May 10	Sept. 30	108	123	109	134
1893, . .	April 21	Nov. 4	74.3	May 8	Sept. 3	143	101	96	168
1894, . .	April 12	Nov. 5	71.5	May 22	Aug. 22	125	107	83	175
1895, . .	April 3	Oct. 20	61.0	May 17	Aug. 22	119	118	110	137
1896, . .	April 7	Nov. 14	44.0	May 1	Sept. 24	108	132	192	132
1897, . .	April 27	Nov. 12	52.8	May 8	Sept. 22	127	108	109	148
1898, . .	April 6	Nov. 24	69.5	April 27	Sept. 21	125	78	138	149
1899, . .	April 16	Oct. 12	52.0	May 4	Sept. 14	110	91	139	135
1900, . .	April 9	Nov. 9	37.0	May 29	Sept. 15	131	83	144	138
1901, . .	April 3	Nov. 11	52.3	May 6	Sept. 26	135	81	105	179
1902, . .	April 2	Oct. 29	57.0	May 14	Sept. 6	144	73	113	179
1903, . .	April 4	Oct. 26	33.5	May 2	Sept. 25	116	119	98	148
1904, . .	April 20	Oct. 12	59.5	April 23	Sept. 22	126	142	96	128
1905, . .	May 1	Nov. 9	40.0	May 24	Sept. 12	122	130	128	107
1906, . .	April 23	Nov. 11	56.2	May 20	Sept. 25	121	130	140	95
1907, . .	May 11	Nov. 23	54.5	May 22	Sept. 27	122	95	155	115
1908, . .	April 20	Nov. 5	38.5	June 3	Sept. 16	109	143	130	93
1909, . .	April 9	Nov. 5	31.0	May 12	Oct. 13	128	112	151	102
1910, . .	Mar. 14	Nov. 8	44.5	May 6	Sept. 23	117	142	152	71
1911, . .	April 19	Nov. 14	35.0	May 5	Sept. 14	120	106	131	128
1912, . .	April 9	Nov. 3	33.8	May 1	Aug. 31	117	71	182	113
1913, . .	April 9	Oct. 31	26.5	May 15	Sept. 10	135	105	144	116

Summary for the Twenty-five Years 1889–1913, inclusive.

Barometer (Pressure in Inches).

Maximum reduced to freezing, Feb. 26, 1889, 11 A.M.,	30.650
Minimum reduced to freezing, Feb. 8, 1895, 7 A.M.,	28.240
Maximum reduced to freezing and sea level, Feb. 26, 1889, 11 A.M.,	30.970
Minimum reduced to freezing and sea level, Jan. 3, 1913, 7 A.M.,	28.550
Mean,	30.012
Total range,	2.420
Greatest annual range, 1913,	2.330
Least annual range, 1905,	1.640
Mean annual range,	1.890
Greatest monthly range, January, 1913,	2.180
Least monthly range, August, 1894,	.440
Mean monthly range,	1.100

Air Temperature (in Degrees F.).

Highest, July 4, 1911, 3.30 P.M.,	104.0
Lowest, Jan. 5, 1904, 7.30 A.M.,	−26.0
Mean,	47.5
Total range,	130.0
Greatest annual range, 1904,	120.5
Least annual range, 1906,	98.5
Mean annual range,	107.6
Greatest monthly range, January, 1907,	78.0
Least monthly range, August, 1901,	33.5
Mean monthly range,	54.6
Greatest daily range, Dec. 10, 1902,	54.0
Least daily range, June 2, 1907,	2.0

Humidity.

Mean dew point,	39.0
Mean relative humidity,	74.6

Precipitation (in Inches).

Total rain or melted snow,	1,093.91
Total snowfall,	1,190.70
Greatest annual precipitation, 1897,	57.05
Least annual precipitation, 1908,	30.68
Mean annual precipitation,	43.76
Greatest monthly precipitation, July, 1897,	14.51
Least monthly precipitation, August, 1894,	.31
Mean monthly precipitation,	3.65

Wind (in Miles).

Total movement,	1,320,668
Greatest annual movement, 1908,	63,571
Least annual movement, 1894,	36,257
Mean annual movement,	52,827
Greatest monthly movement, April, 1908,	8,208
Least monthly movement, July, 1894,	1,109
Mean monthly movement,	4,402
Greatest daily movement, April 8, 1909,	705
Least daily movement, Sept. 29, 1894, March 7, 1890, Jan. 6, 1904,	0
Mean daily movement,	145

Maximum pressure per square foot, 43 pounds, = 93 miles per hour, Sept. 11, 1895, 3 P.M.

Weather.

Mean cloudiness observed, per cent.,	52.2
Total cloudiness by the sun thermometer, per cent.,	48.3
Number of clear days,	2,766
Number of fair days,	3,073
Number of cloudy days,	3,291

Gales of 75 or more miles per hour: 1889, Dec. 26, 76, N.W.; 1893, Aug. 29, 87, S.W.; 1895, Sept. 11, 93, N.E.; 1898, Sept. 7, 78, S.W.; Dec. 4, 75, E.S.E.; 1900, Feb. 22, 78, W.N.W.; 1907, July 20, 81, W.; 1908, April 11, 80, N.N.W.; 1911, Dec. 28, 79, W.N.W.

The following summary was abstracted from meteorological records taken in Amherst prior to the establishment of the meteorological observatory at the college in 1889.

The records from 1836 to 1883 are from the observations of the late Prof. E. S. Snell of Amherst College. These records were taken at his house, about one and a half miles south of the location of the meteorological observatory at the Massachusetts Agricultural College, and at practically the same elevation above sea level.

The precipitation records are believed to be fairly comparable with the records of this station, although perhaps slightly affected by the difference of topography surrounding the two places. As Professor Snell changed his time of taking temperatures, and used different methods of deducing the mean temperatures in conformity with the current practices at different dates, the comparison with those of this station should be made with more caution. The maximum and minimum temperatures of the earlier years were not all taken with self-registering instruments, and this fact should be taken into consideration when comparisons are made.

The records from 1883 to 1889 were taken at the State Experiment Station, on the college grounds, under the direction of Dr. C. A. Goessmann, at that time the director of the State Agricultural Experiment Station, and are fairly comparable with the records of this station.

Mean temperature for seventy-seven years: —

$$\frac{47.5\times25+46.7\times52}{77}=46.9 \text{ degrees.}$$

Mean precipitation for seventy-eight years: —

$$\frac{44.36\times53+43.76\times25}{78}=44.17 \text{ inches.}$$

Record of the Rainfall in Inches from 1836 to 1888, inclusive.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1836, . .	4.21	3.83	3.13	1.98	2.59	3.45	6.02	0.96	2.28	3.02	3.49	5.80	40.76
1837, . .	1.75	2.42	2.65	4.33	5.76	4.49	7.35	2.57	1.07	2.06	1.90	2.35	38.70
1838, . .	2.45	1.67	1.69	2.02	3.63	4.90	2.27	3.95	6.38	4.12	5.77	0.96	39.81
1839, . .	1.66	1.75	1.69	4.14	3.49	3.30	9.56	2.51	2.82	1.78	3.04	7.09	42.83
1840, . .	3.15	2.03	3.18	3.98	1.91	4.60	3.34	6.82	5.20	5.04	4.61	3.15	47.01
1841, . .	5.80	1.50	2.85	4.52	3.47	1.65	2.55	3.18	3.50	3.73	2.80	6.08	41.63
1842, . .	1.02	3.78	2.39	2.92	2.40	3.18	1.95	7.42	3.23	2.84	3.73	3.19	38.05
1843, . .	1.99	3.49	5.73	4.82	2.09	5.18	2.53	9.38	1.57	9.45	3.07	2.28	51.58
1844, . .	3.44	2.18	4 12	0.57	5.59	3.00	3.81	4.93	1.84	6.49	2.12	2.49	40.58
1845, . .	4.97	3.37	3.56	1.70	2.42	2.57	3.31	2.79	2.58	4.66	3.90	3.91	39.74
1846, . .	2.74	2.55	4.35	1.54	4.33	3.10	3.25	2.44	0.47	2.09	4.96	3.10	34.92
1847, . .	4.86	4.88	3.57	1.41	1.91	4.44	4.48	4.06	3.63	3.99	4.17	6.41	47.81
1848, . .	2.92	2.60	3.03	1.55	6.18	2.58	4.72	1.53	2.49	3.15	3.09	5.54	39.38
1849, . .	0.99	0.99	4.21	2.24	3.61	1.53	2.25	7.86	1.40	6.36	3.65	3.36	38.45
1850, . .	4.75	3.56	1.86	3.93	8.72	2.88	6.81	6.50	4.93	3.65	2.63	5.37	55.59
1851, . .	1.66	5.07	1.28	4.43	4.07	3.69	4.31	3.03	2.05	5.43	5.30	3.17	43.50
1852, . .	2.42	3.35	3.26	4.71	2.30	2.54	3.38	5.19	2.48	1.76	6.43	4.88	42.70
1853, . .	2.11	6.69	2.39	3.79	5.40	2.64	3.59	7.13	5.66	3.75	6.24	1.84	51.23
1854, . .	2.01	4.53	3.11	8.33	3.19	1.75	3.53	0.99	5.46	2.31	7.48	2.39	45.08
1855, . .	5.06	2.70	1.08	3.85	1.49	5.19	6.10	2.55	0.55	10.08	4.12	5.41	48.18
1856, . .	2.48	0.79	1.12	2.51	5.31	1.92	1.96	12.13	3.47	1.40	2.85	4.19	40.13
1857, . .	3.55	2.41	2.12	7.68	6.82	2.66	4.98	3.14	3.04	3.88	2.07	5.31	47.66
1858, . .	3.52	1.60	0.80	3.20	2.98	4.62	6.73	4.82	4.14	3.86	2.16	3.16	41.59
1859, . .	4.89	3.54	6.27	2.96	4.08	6.16	2.61	6.65	4.47	1.85	2.96	4.85	51.29
1860, . .	1.21	2.93	1.58	1.28	4.57	3.57	6.13	2.68	6.12	2.18	3.52	3.84	39.61
1861, . .	4.34	3.28	3.76	5.65	4.45	2.69	5.23	4.10	2.75	4.53	3.93	2.17	46.88
1862, . .	5.25	2.84	4.20	2.28	2.33	11.69	5.12	2.98	2.12	3.28	4.76	1.91	48.86
1863, . .	5.05	4.43	5.60	2.33	3.59	4.09	8.64	6.11	2.16	4.04	5.28	4.87	56.19
1864, . .	2.20	1.12	2.58	2.57	2.54	1.38	0.96	4.40	2.92	2.94	6.20	4.63	34.44
1865, . .	3.48	2.88	5.98	2.90	7.89	2.94	3.72	1.86	0.37	4.98	2.45	3.54	42.99
1866, . .	1.36	4.62	3.16	2.03	4.48	5.66	4.02	3.96	4.71	3.38	3.86	3.57	44.81
1867, . .	1.32	3.65	3.12	3.79	4.61	5.67	4.00	9.16	1.11	3.85	4.31	1.51	46.10
1868, . .	3.52	1.03	3.25	4.27	7.66	2.44	3.28	5.67	10.63	1.37	4.80	1.47	49.59
1869, . .	3.47	4.14	5.46	1.53	5.65	5.99	2.98	1.04	4.32	11.36	2.59	4.96	53.49
1870, . .	5.87	5.25	2.71	3.70	1.72	2.73	2.53	2.83	1.75	4.49	3.28	1.84	38.70
1871, . .	1.96	2.91	3.99	3.09	3.82	6.58	3.52	6.45	1.30	6.09	3.51	2.67	45.89
1872, . .	1.51	1.89	2.87	2.20	3.11	3.25	7.07	5.28	6.20	3.64	4.48	2.69	44.19
1873, . .	5.01	2.17	3.13	1.74	3.91	1.59	2.93	3.47	4.77	6.36	3.51	3.31	41.90
1874, . .	5.46	2.19	1.35	6.03	5.22	5.06	11.58	2.69	1.82	1.85	3.54	1.17	47.96
1875, . .	2.90	3.62	4.20	3.33	2.19	2.89	8.15	6.17	4.65	3.89	3.97	1.03	46.99
1876, . .	2.31	5.53	7.14	3.11	3.96	3.87	4.84	0.27	3.71	1.12	2.49	3.22	41.57
1877, . .	2.52	0.36	6.97	2.45	1.93	4.59	6.47	2.79	0.91	6.99	5.44	1.02	42.44
1878, . .	3.58	3.67	2.57	5.85	2.36	6.00	2.16	6.97	2.82	2.05	5.34	6.02	49.39
1879, . .	1.75	3.49	2.98	3.85	3.32	5.37	5.75	5.89	2.59	1.80	2.35	4.85	45.99
1880, . .	4.58	3.60	2.68	2.64	1.90	1.40	6.34	2.91	2.69	2.27	2.50	2.29	35.80
1881, . .	4.01	1.77	4.86	1.65	4.28	3.95	1.50	2.76	2.37	4.24	4.58	6.15	42.12
1882, . .	5.44	4.23	5.20	1.52	6.50	2.25	1.83	0.25	11.85	1.67	1.33	1.47	43.54
1883, . .	3.24	4.03	1.70	2.18	6.20	3.99	3.69	1.57	3.17	4.31	1.80	2.99	38.87
1884, . .	3.60	4.62	5.67	2.48	2.02	1.38	3.75	5.10	1.25	2.40	2.53	5.58	40.38
1885, . .	3.78	3.88	0.86	3.38	3.08	3.49	2.07	8.31	0.85	3.65	5.54	3.54	42.43
1886, . .	5.39	3.94	3.31	1.73	3.10	2.33	3.82	2.60	5.48	2.97	5.25	3.61	43.53
1887, . .	4.57	5.05	4.05	2.98	1.13	5.09	8.93	7.75	1.22	2.10	3.35	4.11	50.33
1888, . .	3.87	3.94	5.96	3.08	4.29	5.40	3.63	4.29	10.70	5.19	3.91	3.78	58.04
Mean, .	3.34	3.18	3.44	3.18	3.88	3.76	4.45	4.39	3.43	3.88	3.83	3.59	44.36

Record of the Mean Temperature from 1837 to 1888, inclusive.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1837, . .	20.3	26.7	33.7	47.4	57.9	68.2	70.6	68.6	61.4	50.0	40.2	27.6	47.7
1838, . .	32.0	19.6	36.4	40.7	54.3	68.6	71.9	68.2	62.7	46.5	34.1	23.5	46.5
1839, . .	24.6	29.8	37.5	52.2	60.7	65.4	74.4	70.7	63.5	53.3	36.6	28.9	49.8
1840, . .	14.4	28.5	35.0	49.0	57.1	65.5	70.6	70.3	57.2	47.4	37.0	23.6	46.3
1841, . .	25.6	20.2	31.9	41.6	54.4	68.4	69.5	69.8	61.2	42.8	35.3	29.5	45.8
1842, . .	25.6	30.5	37.7	46.5	52.7	64.1	71.5	69.0	57.4	47.4	35.1	24.2	46.8
1843, . .	29.7	16.5	24.5	44.6	56.0	65.3	68.8	69.8	61.7	45.0	34.0	28.0	45.3
1844, . .	13.9	22.1	35.5	52.0	57.8	65.6	68.2	68.0	59.6	47.6	35.7	27.3	46.0
1845, . .	24.5	24.9	36.9	45.6	56.2	66.7	72.1	71.5	58.3	49.6	41.5	21.5	47.4
1846, . .	24.8	20.1	36.3	50.1	58.3	65.0	70.7	69.6	65.5	47.6	43.0	25.3	48.0
1847, . .	25.5	24.7	29.2	43.3	57.5	64.7	72.4	69.3	59.3	46.0	43.2	34.2	47.4
1848, . .	29.0	23.7	32.6	43.3	59.5	67.6	69.4	70.6	57.4	47.3	33.5	30.6	47.0
1849, . .	20.0	18.5	35.6	43.5	53.4	66.9	72.1	68.8	60.0	47.0	44.1	28.4	46.5
1850, . .	25.9	28.4	32.4	42.9	53.4	67.3	72.1	67.1	59.4	48.2	40.0	23.4	46.7
1851, . .	23.8	27.9	35.5	46.2	55.6	69.6	69.2	66.2	60.9	51.0	34.5	20.2	46.2
1852, . .	19.6	25.2	30.9	39.4	56.0	65.4	70.0	65.2	58.4	49.3	36.4	32.8	45.7
1853, . .	24.3	26.7	33.8	44.0	56.7	67.0	68.7	67.8	59.5	46.8	39.1	26.3	46.7
1854, . .	22.8	22.0	31.6	43.5	59.5	66.7	74.1	68.8	61.5	51.5	40.3	22.3	47.0
1855, . .	27.3	19.8	31.5	43.8	56.6	65.0	70.9	65.5	60.8	49.7	38.8	28.2	46.5
1856, . .	15.2	19.0	25.9	46.4	53.6	68.6	72.9	66.2	60.8	48.7	37.5	23.2	44.8
1857, . .	13.5	31.4	31.1	41.0	55.2	63.6	70.9	67.2	59.9	48.9	39.5	31.5	46.1
1858, . .	28.8	20.6	31.3	44.4	54.1	66.1	69.8	67.9	50.9	51.4	33.9	25.7	45.4
1859, . .	22.9	25.6	36.7	43.4	59.2	62.8	67.7	66.4	57.1	45.7	41.1	23.0	46.0
1860, . .	26.5	24.8	37.2	44.0	57.3	65.2	66.4	68.0	56.8	48.8	42.7	23.9	46.8
1861, . .	20.4	29.2	32.5	45.5	53.4	65.5	69.5	65.7	59.9	51.5	37.8	29.0	46.7
1862, . .	22.3	22.1	32.2	43.6	58.1	63.4	68.0	68.1	61.1	51.0	39.6	27.6	46.4
1863, . .	29.1	26.3	26.1	45.5	55.4	59.0	70.9	70.1	57.4	49.9	41.1	25.3	46.3
1864, . .	24.4	28.5	34.4	43.5	60.4	65.7	71.5	70.8	57.8	46.4	38.0	38.2	48.3
1865, . .	18.7	25.0	37.1	49.0	57.1	69.3	69.1	68.6	65.6	46.0	39.9	28.9	47.8
1866, . .	21.9	26.2	31.6	48.6	54.6	65.8	72.9	63.5	60.0	49.5	40.1	26.3	46.7
1867, . .	18.3	31.2	30.8	45.5	54.0	67.1	68.1	68.6	60.0	49.9	37.9	22.6	46.2
1868, . .	20.2	18.2	33.8	42.0	55.1	66.2	74.0	69.0	59.5	45.3	36.5	22.8	45.2
1869, . .	28.0	28.0	27.3	46.4	55.9	64.7	69.1	66.9	62.1	46.7	35.9	27.5	46.5
1870, . .	30.8	25.3	30.9	48.3	58.3	70.4	73.6	71.1	62.3	52.0	39.1	28.0	49.2
1871, . .	23.3	26.0	40.5	48.0	57.8	65.4	69.2	68.9	52.8	51.0	34.0	24.6	46.8
1872, . .	25.1	24.2	25.3	45.0	59.1	68.1	72.6	71.6	61.7	48.2	36.4	19.5	46.4
1873, . .	20.6	24.0	30.6	43.2	54.6	67.5	71.3	67.0	60.4	49.9	29.7	29.2	45.7
1874, . .	28.2	24.5	32.9	38.3	56.5	66.2	67.2	65.6	62.0	47.6	36.2	29.2	46.2
1875, . .	16.7	17.5	27.8	40.8	57.1	65.8	69.3	68.9	57.3	47.9	33.1	28.3	44.2
1876, . .	29.8	26.4	31.6	43.6	57.5	70.6	74.2	70.5	59.1	45.5	40.5	19.7	47.4
1877, . .	20.0	30.8	33.3	47.8	58.5	67.8	71.1	71.4	63.3	50.5	41.9	33.1	49.1
1878, . .	25.3	27.1	39.2	52.2	57.4	64.7	73.3	68.6	63.2	54.4	39.1	29.0	49.5
1879, . .	21.6	22.4	33.0	43.2	60.6	66.3	71.0	67.2	59.0	56.0	37.4	30.8	47.4
1880, . .	31.6	29.1	33.5	47.5	64.2	68.5	71.8	67.5	63.2	47.3	34.9	22.8	48.5
1881, . .	17.9	24.9	36.2	43.6	61.7	62.8	70.6	70.5	67.4	52.5	40.3	36.0	48.7
1882, . .	23.6	28.2	35.1	44.3	52.9	66.8	71.9	70.9	63.2	52.7	36.4	26.6	47.7
1883, . .	21.0	25.0	27.3	44.3	58.6	69.7	70.4	66.4	59.4	46.8	40.4	27.0	46.4
1884, . .	21.6	30.9	32.9	46.7	57.4	69.0	68.6	69.2	64.4	50.3	38.4	30.0	48.3
1885, . .	22.7	15.2	23.3	45.3	54.8	63.8	70.4	66.0	58.3	49.1	39.8	29.6	44.9
1886, . .	21.8	35.1	33.5	50.4	57.3	63.2	68.8	66.3	59.5	48.9	38.3	23.0	46.2
1887, . .	19.4	24.2	26.4	41.6	60.9	65.7	73.7	64.9	55.9	47.0	36.5	26.6	45.2
1888, . .	13.8	22.0	26.8	40.4	54.7	65.8	67.2	67.4	57.1	43.1	38.9	30.4	44.0
Mean, .	23.0	24.7	32.4	45.1	56.9	66.1	70.7	68.3	60.1	48.7	38.0	27.0	46.7

Record of the Maximum Temperature from 1838 to 1888, inclusive.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1838, . .	55.0	42.0	58.0	67.0	80.0	90.0	92.0	88.0	85.0	77.0	57.0	43.0	92.0
1839, . .	50.0	50.0	65.0	72.0	80.0	84.0	86.0	85.0	80.0	70.0	56.0	53.0	86.0
1840, . .	38.0	56.0	64.0	79.0	88.0	88.0	94.0	90.0	77.0	72.0	55.0	44.0	94.0
1841, . .	50.0	44.0	60.0	67.0	81.0	90.0	94.0	88.0	84.0	64.0	68.0	44.0	94.0
1842, . .	37.0	55.0	68.0	82.0	78.0	84.0	90.0	82.0	84.0	70.0	60.0	43.0	90.0
1843, . .	50.0	37.0	42.0	70.0	82.0	86.0	91.0	84.0	87.0	69.0	57.0	40.0	91.0
1844, . .	39.0	49.0	56.0	83.0	84.0	86.0	86.0	84.0	83.0	70.0	54.0	45.0	86.0
1845, . .	46.0	55.0	71.0	77.0	88.0	90.0	94.0	89.0	81.0	74.0	65.0	38.0	94.0
1846, . .	45.0	40.0	59.0	76.0	83.0	87.0	93.0	90.0	88.0	81.0	61.0	45.0	93.0
1847, . .	44.0	47.0	52.0	77.0	84.0	88.0	91.0	85.0	85.0	67.0	70.0	59.0	91.0
1848, . .	56.0	43.0	64.0	74.0	86.0	90.0	87.0	87.0	81.0	70.0	52.0	58.0	90.0
1849, . .	46.0	43.0	60.0	68.0	83.0	92.0	93.0	83.0	70.0	68.0	63.0	43.0	93.0
1850, . .	45.0	52.0	60.0	70.0	73.0	90.0	87.0	87.0	80.0	67.0	63.0	49.0	90.0
1851, . .	48.0	48.0	73.0	67.0	82.0	88.0	87.0	83.0	80.0	73.0	56.0	44.0	88.0
1852, . .	43.2	47.4	53.0	61.0	79.0	84.0	90.0	85.7	85.0	70.0	50.8	56.0	90.0
1853, . .	45.0	51.0	56.4	76.3	84.2	91.3	85.1	91.7	84.7	69.0	59.5	42.8	91.7
1854, . .	50.4	45.0	65.4	70.6	79.0	87.5	97.0	88.5	90.0	75.8	66.0	41.5	97.0
1855, . .	48.0	42.0	57.8	76.0	81.0	92.0	91.6	84.5	85.0	73.0	63.0	46.2	92.0
1856, . .	34.8	38.6	44.9	76.7	89.0	94.0	95.0	87.3	78.9	75.5	61.0	41.8	95.0
1857, . .	37.1	61.8	54.5	58.3	86.4	86.9	90.3	90.3	85.7	73.0	67.0	52.0	90.3
1858, . .	51.4	47.1	57.7	68.1	74.2	90.3	92.0	79.0	85.2	73.0	59.0	42.8	92.0
1859, . .	39.4	44.1	56.6	71.0	86.0	91.5	90.0	81.8	73.8	75.0	65.8	62.9	91.5
1860, . .	50.3	52.0	71.3	68.3	81.0	83.0	84.0	84.4	79.0	69.9	66.7	37.5	84.4
1861, . .	38.0	53.5	56.3	80.3	77.2	84.0	91.7	90.0	82.3	75.5	64.0	51.4	91.7
1862, . .	42.9	40.0	44.5	72.9	84.0	86.0	90.0	88.0	80.0	83.0	68.2	52.0	90.0
1863, . .	52.0	45.3	47.3	77.0	88.0	85.6	85.5	90.0	80.0	71.0	65.4	51.5	90.0
1864, . .	44.2	46.8	53.8	64.8	86.0	93.5	91.9	98.0	80.0	68.7	62.0	49.4	98.0
1865, . .	39.5	45.4	63.7	79.5	85.8	87.0	85.4	90.0	89.0	72.0	68.0	54.9	90.0
1866, . .	40.0	55.0	55.8	84.2	80.0	90.1	94.0	81.6	83.1	73.0	60.8	51.2	94.0
1867, . .	33.5	50.0	53.0	66.0	75.5	85.0	90.0	83.5	80.0	76.0	65.0	46.0	90.0
1868, . .	39.5	45.0	59.8	67.5	75.0	88.7	94.5	85.0	79.5	68.0	58.0	42.7	94.5
1869, . .	49.0	50.6	53.8	74.0	83.0	80.7	89.9	87.2	85.0	71.4	56.9	45.3	89.9
1870, . .	54.3	55.0	50.5	78.0	82.4	93.0	91.2	91.3	83.5	71.5	61.0	47.0	93.0
1871, . .	50.0	50.6	55.5	74.8	92.8	88.2	85.6	85.0	78.0	73.1	62.0	43.3	92.8
1872, . .	42.9	50.0	44.0	84.0	84.1	91.8	91.7	88.8	88.5	69.0	54.0	40.3	91.8
1873, . .	42.3	45.0	49.3	66.2	82.0	90.0	92.4	86.2	85.8	70.5	52.0	57.7	92.4
1874, . .	52.0	49.3	57.2	63.0	86.0	93.0	90.0	84.0	85.8	66.0	60.0	49.0	93.0
1875, . .	35.5	50.0	51.0	63.0	84.7	89.0	91.5	84.8	84.7	70.3	56.2	55.0	91.5
1876, . .	63.0	52.3	59.0	63.3	86.0	87.7	95.0	90.0	90.0	71.1	71.7	42.0	95.0
1877, . .	43.0	50.0	52.8	75.8	84.5	88.0	89.1	87.4	85.7	75.4	66.8	55.2	89.1
1878, . .	44.4	53.3	65.1	73.1	83.2	90.2	92.2	83.3	84.5	77.3	57.2	53.7	92.2
1879, . .	50.1	43.2	51.6	72.4	83.0	90.3	91.4	90.6	85.6	82.6	68.2	54.5	91.4
1880, . .	47.9	57.6	59.8	77.7	93.0	91.1	90.5	88.0	90.0	71.4	59.2	38.9	93.0
1881, . .	38.0	47.0	50.8	78.4	89.0	80.0	87.2	90.8	94.0	86.2	66.7	61.4	94.0
1882, . .	45.0	47.4	56.2	68.0	78.0	90.0	92.1	93.0	87.7	73.8	66.1	48.0	93.0
1883, . .	42.2	43.1	51.1	67.3	89.0	90.8	93.0	86.2	79.8	77.1	67.2	53.1	93.0
1884, . .	40.1	46.0	54.0	70.3	85.2	92.5	93.0	92.4	90.0	78.2	61.0	57.4	93.0
1885, . .	57.0	39.0	50.0	83.0	85.0	89.0	93.0	87.0	81.0	80.0	70.0	65.0	93.0
1886, . .	56.0	52.0	61.0	83.0	82.0	82.0	95.0	90.0	83.8	77.9	65.5	49.0	95.0
1887, . .	47.2	43.8	46.0	74.4	86.5	91.0	93.6	88.0	80.0	74.4	64.8	51.0	93.6
1888, . .	41.0	49.0	49.0	84.0	80.0	94.5	85.5	87.0	76.0	66.0	71.0	56.5	94.5
Mean, .	45.5	47.9	56.3	73.0	83.2	88.6	90.7	87.2	83.2	72.9	62.1	48.9	91.9

Record of the Minimum Temperature from 1838 to 1888, inclusive.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1838,	6.0	—5.5	4.0	17.0	30.0	43.0	50.0	41.0	38.0	27.0	3.0	—7.0	—7.0
1839,	—13.0	0.0	4.0	22.0	27.0	40.0	49.0	44.0	34.0	22.0	11.0	—2.0	—13.0
1840,	—21.0	—14.0	7.0	19.0	34.0	44.0	50.0	50.0	36.0	23.0	18.0	—2.0	—21.0
1841,	—17.0	—6.0	8.0	21.0	29.0	43.0	42.0	42.0	46.0	20.0	13.0	5.0	—17.0
1842,	—10.0	5.0	13.0	17.0	30.0	34.0	49.0	45.0	30.0	26.0	13.0	—2.0	—10.0
1843,	—8.0	—15.0	7.0	15.0	35.0	34.0	47.0	53.0	30.0	28.0	17.0	2.0	—15.0
1844,	—22.0	—10.0	5.0	14.0	33.0	42.0	40.0	46.0	26.0	25.0	3.0	—5.0	—22.0
1845,	0.0	—3.0	8.0	24.0	30.0	41.0	46.0	42.0	32.0	17.0	12.0	—10.0	—10.0
1846,	—1.0	—6.0	2.0	22.0	32.0	41.0	44.0	47.0	37.0	25.0	20.0	1.0	—6.0
1847,	4.0	—8.0	9.0	5.0	34.0	42.0	46.0	48.0	35.0	15.0	5.0	3.0	—8.0
1848,	—12.0	—2.0	4.0	25.0	32.0	39.0	49.0	44.0	31.0	28.0	11.0	—3.0	—12.0
1849,	—8.0	—10.0	12.0	21.0	32.0	39.0	45.0	50.0	37.0	29.0	25.0	3.0	—10.0
1850,	—2.0	—11.0	8.0	19.0	31.0	44.0	48.0	44.0	32.0	23.0	16.0	—15.0	—15.0
1851,	—5.0	—8.0	12.0	24.0	30.0	41.0	49.0	39.0	29.0	31.0	13.0	—15.0	—15.0
1852,	—15.0	—3.4	0.3	23.3	38.5	43.9	55.0	48.9	33.0	24.3	15.0	6.1	—15.0
1853,	—2.5	0.5	7.6	27.4	31.8	39.0	54.0	45.9	37.0	24.9	13.8	7.2	—2.5
1854,	—9.6	—4.8	14.0	23.7	34.0	39.8	57.7	50.8	33.8	27.0	14.0	—9.0	—9.6
1855,	10.7	—16.0	7.8	17.0	41.5	48.0	57.2	44.7	33.0	30.2	15.0	7.0	—16.0
1856,	—7.5	—11.0	—9.0	16.5	38.2	48.0	55.9	48.2	41.8	25.0	18.0	—7.0	—11.0
1857,	—18.2	—2.7	7.0	14.3	39.8	49.0	55.5	53.6	32.0	25.0	13.0	2.2	—18.2
1858,	0.0	—5.0	—8.0	28.5	40.3	51.0	58.5	58.8	37.0	31.5	14.6	0.0	—8.0
1859,	—19.4	2.8	3.5	28.7	43.9	45.0	53.0	47.4	41.0	24.8	24.0	—8.5	—19.4
1860,	—8.0	—7.2	22.8	23.1	38.9	52.0	53.0	49.1	32.0	28.0	15.0	—7.0	—8.0
1861,	—17.0	—20.0	5.5	18.2	33.0	51.0	56.7	48.5	41.6	25.0	17.0	—6.5	—20.0
1862,	0.0	—2.0	13.8	24.3	44.0	49.5	51.9	48.0	39.0	26.0	18.0	—1.3	—2.0
1863,	5.0	—9.0	—6.0	25.0	38.3	51.0	55.3	48.7	32.0	21.0	18.0	3.2	—9.0
1864,	—1.5	—4.3	15.0	31.8	40.0	47.3	53.9	54.8	41.0	28.5	10.8	18.0	—4.3
1865,	—4.5	—1.0	13.0	33.0	42.8	55.9	54.8	47.5	35.0	24.2	18.5	6.8	—4.5
1866,	—14.5	—1.5	11.5	30.0	40.0	48.0	55.0	48.0	35.5	26.5	16.8	—3.8	—14.5
1867,	—5.0	8.0	8.0	29.0	36.0	54.0	55.3	48.3	39.0	27.0	17.5	—3.0	—5.0
1868,	0.0	—18.3	—7.3	23.0	36.0	51.8	61.0	51.0	36.2	19.2	23.8	—5.0	—18.3
1869,	3.0	—1.0	—9.0	26.7	35.2	47.4	53.5	50.0	36.3	26.8	16.9	—7.5	—9.0
1870,	5.0	6.2	6.5	35.0	42.8	53.5	54.5	47.0	40.0	26.0	24.7	1.0	1.0
1871,	—5.5	—9.5	24.8	27.0	41.0	51.8	54.0	50.0	32.0	24.3	7.0	—6.5	—9.5
1872,	2.5	—2.5	—4.8	29.0	43.7	48.7	59.1	52.9	39.5	29.9	10.0	—8.0	—8.0
1873,	—22.0	—2.5	1.8	33.5	39.0	50.6	56.1	49.1	36.2	27.0	6.5	7.0	—22.0
1874,	1.2	—5.0	9.7	18.7	39.0	51.3	38.0	46.3	39.0	28.5	16.0	0.0	—5.0
1875,	—8.2	—4.0	0.0	22.5	39.8	48.5	53.8	32.0	32.5	26.0	—1.0	—9.0	—9.0
1876,	2.8	—1.0	4.5	28.0	39.0	47.0	52.5	49.0	41.2	23.0	18.9	—1.0	—1.0
1877,	—3.5	8.5	10.0	32.5	40.0	54.7	58.1	54.8	39.0	25.3	19.4	13.0	—3.5
1878,	12.5	—3.2	13.2	37.0	40.5	46.4	55.2	49.9	37.0	27.0	19.8	11.7	—12.5
1879,	—4.5	1.0	7.0	32.7	40.0	49.0	56.7	53.2	30.4	20.8	7.7	—6.0	—6.0
1880,	2.0	—11.5	13.7	26.2	37.0	51.0	54.0	45.7	39.1	22.9	9.5	—5.0	—11.5
1881,	—12.4	—7.0	24.4	22.1	37.0	47.7	59.2	56.7	49.0	29.0	14.0	8.5	—12.4
1882,	—15.0	—6.0	17.4	23.7	39.1	52.2	56.3	49.7	43.7	32.2	12.0	0.0	—15.0
1883,	—2.5	—1.3	3.0	23.5	43.0	53.7	55.0	43.4	36.2	23.2	18.0	—12.8	—12.8
1884,	—8.0	5.1	0.0	31.2	37.6	50.0	57.1	48.8	39.0	26.5	19.8	—10.0	—10.0
1885,	—18.0	—15.0	—11.0	19.0	21.0	35.0	41.0	34.0	27.0	24.0	11.0	6.0	—18.0
1886,	—22.0	—11.0	—1.0	21.0	29.0	40.0	41.0	39.0	31.6	17.0	15.9	0.8	—22.0
1887,	—22.2	—3.8	—2.4	17.1	33.2	38.5	56.0	42.5	29.5	17.0	11.0	—6.0	—22.2
1888,	—21.5	—19.0	—3.0	15.0	26.0	38.0	46.0	42.0	25.0	26.0	5.7	3.5	—21.5
Mean,	—7.4	—5.3	6.0	23.6	36.1	45.9	52.1	47.3	35.6	25.1	14.2	—1.3	—11.7

ALFALFA.

Since the methods of producing this crop, and the conditions under which it promises to be successful are not yet generally understood, it is the plan to present in this paper first, a brief general discussion of the characteristics and value of the crop; second, the results of the most recent experiments on the station grounds; third, results obtained by farmers who have been growing the crop in co-operation with the station; and fourth, brief general directions based upon long-continued experiments for starting and managing the crop.

Characteristics and Value of Alfalfa.

Alfalfa is an exceptionally deep-rooted legume, and under the best conditions it is long lived. Like other legumes it has the capacity, under the right conditions, of assimilating nitrogen from the atmosphere, but until the root system and the nodules which it bears are well developed its growth is greatly promoted by the presence of readily assimilable nitrogen in the soil. It is without doubt one of the most valuable forage plants known to man. It has long been cultivated in various parts of Asia and Europe, whence it was brought to Mexico by the Spaniards, who took it with them to California and the semi-arid portions of our southwestern States. During the past fifteen or twenty years its culture has been steadily pushed eastward, and it is now successfully grown in most parts of the United States and in a few parts of Canada. In many essentials and in feeding value alfalfa resembles the clovers; and as these are so generally known its characteristics will be perhaps best brought out by comparison.

ALFALFA COMPARED WITH CLOVERS.

Longer Lived. — Alfalfa is a perennial, while individual plants of the red and alsike clovers, as a rule, live but two years. In regions without excessive rainfall, and in soils richly stocked with lime and thoroughly well drained, a stand of alfalfa is more permanent than a stand of clover under conditions existing in Massachusetts, but in this connection it is important to recognize two facts: —

1. That alfalfa in our soils and in our climate is much less permanent than in the west.[1] Experience everywhere indicates that the probability is that alfalfa will be gradually crowded out here by perennial grasses and clovers, most prominent among which are the Kentucky blue grass and white clover.
2. That it is possible to retain red and alsike clovers in permanent mowings without reseeding, provided a suitable system of top-dressing is followed.

Relative Yield. — Alfalfa grows more rapidly in early spring than either red or alsike clover, and starts more quickly after cutting, and accordingly it may usually be counted upon to give three crops during the season, whereas clover will usually give but two. The first cut of alfalfa is generally superior to either of the others. The total yield on good soils is likely to range from about 3 to 5 tons per acre of well-cured hay in the three cuttings, while red or alsike clovers on similar soils are likely to give about one-quarter less total yield in two cuttings.

Finer Stems. — The stem of the alfalfa plant is relatively finer than that of the red clover. It accordingly cures more rapidly and is usually more palatable, and is consumed with less waste than the coarser red or mammoth clover.

Nutritive Value. — It is popularly supposed, and quite generally stated, that alfalfa is much superior in nutritive value to clovers, but so far as can be determined by chemical analyses made in this station, and determinations of digestibility which have been made here in the department of plant and animal chemistry and in other stations, this does not appear to be the case.

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[1] The winter of 1913-14 has proved very destructive (see p. 170).

Composition of Clover and Alfalfa Hays.

	Number of Analyses.	Water (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
Alfalfa hay,	4	13.24	6.38	13.98	28.48	34.70	1.40
Alsike clover hay,	8	15.00	9.70	14.00	23.10	36.10	2.10
Medium red clover hay,	15	15.00	7.70	13.30	24.30	37.20	2.50

Digestible Nutrients and Energy Values.[1]

	Protein (Pounds in 100).	Fiber (Pounds in 100).	Nitrogen-free Extract (Pounds in 100).	Fat (Pounds in 100).	Net Energy Value (Therms).
Alfalfa hay,	10.2	13.9	24.4	.5	34.9
Alsike clover hay,	9.2	11.6	23.8	.8	34.6
Medium red clover hay,	7.7	13.1	24.2	1.4	35.6

It will be noted that alfalfa is relatively somewhat richer in digestible protein than the clovers, but considerably lower in fat. The net energy values, or in other words the productive food values, of alfalfa and the clovers are shown by the trials reported to have been substantially equal.

SOIL IMPROVEMENT.

It has been recognized since the time of the Roman empire, and was perhaps even before that period, that the growth of clover improves the soil, and that all crops give superior results when following it. This knowledge of the facts profoundly affected farm practice many centuries before the peculiarly beneficial effects of clover could be fully explained. We now know that they are a consequence chiefly of two causes: —

1. The penetration of the subsoil by the vigorous root system, opening, mellowing and enriching it.

2. The assimilation of large amounts of atmospheric nitrogen a portion of which remains in the roots and stubble even when the crop is harvested and removed. In both these respects

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[1] Based upon average results in the United States.

alfalfa under the best conditions excels the clovers. Its roots penetrate more deeply, and the total crop residue — root and stubble — is greater.

The Soil for Alfalfa.

Alfalfa will thrive on soils of many different kinds, but whatever the type it must satisfy certain conditions: —

1. It should have good depth and be rich, especially in the mineral elements of plant food. Medium loams, inclining rather to be somewhat heavy than light, will give the best crops. The soils which contain too large a proportion of clay retain so much moisture that in open winters the crop, especially when young, is liable to heave.

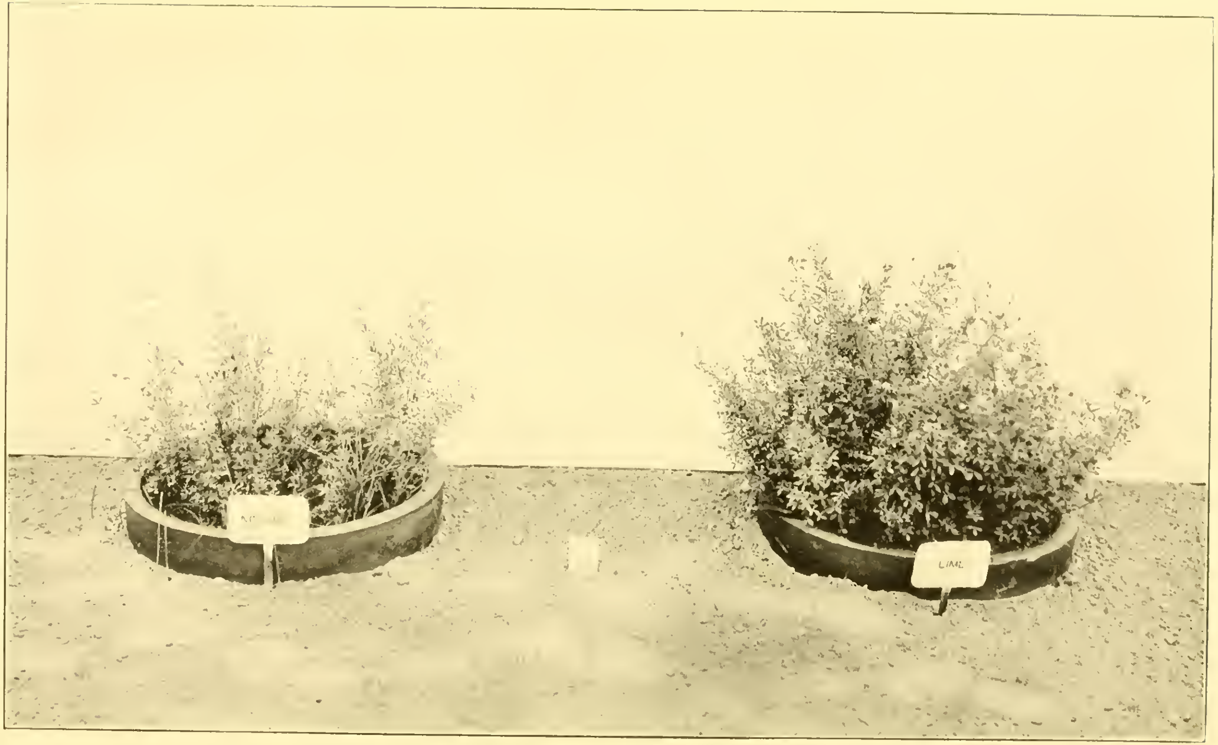
2. Stagnant water in the subsoil is highly injurious. In soils with good capacity to conduct and retain water the presence of standing water in the subsoil (determined by sinking trial holes) within less than 5 or 6 feet of the surface will be highly injurious. If the subsoil be free from standing water to much greater depth it will be a distinct advantage. In the case of soils of coarser texture, which do not conduct water freely in large quantities, and which have deficient capacity to retain water, the water table may be nearer the surface without disadvantage, but even with such soils it would, doubtless, be inadvisable to attempt the cultivation of alfalfa with standing water nearer than 4 or 5 feet below the surface.

3. The field must have sufficient surface slope to carry off water, and there must be no pockets which will retain water. In fields which are too level, or in pockets, the formation of ice on the surface is fatal to alfalfa. It is, of course, possible that in this climate ice may sometimes form on the surface, even on considerable slopes, but this is a danger which cannot be avoided, and it is least on slopes.

4. The presence of a hardpan within less than 10 or 12 feet of the surface, or an excessively compact subsoil, will prove unfavorable; so, also, will a shallow soil underlaid by rock.

5. The soil must not contain free acid, though if this condition exists at the start it can be corrected by the use of lime.

6. The richer the soil naturally is in lime the better suited it is likely to be for alfalfa.


LIME

7. Where sweet clover grows abundantly wild, and where the beech tree occurs in large numbers, alfalfa will usually do well. This is because both sweet clover and the beech are lime-loving plants, and in the case of the sweet clover, moreover, because the bacteria which give it capacity to assimilate atmospheric nitrogen are either identical with those essential for alfalfa or so closely related that they serve the purpose. Inoculation for alfalfa is, therefore, unnecessary in sections where sweet clover grows spontaneously in abundance.

Lime Necessary.

Alfalfa, as already stated, is a lime-loving plant. The soils in many parts of this State are relatively deficient in this element. In most localities, therefore, an application of lime is one of the most important steps in the preparation of a soil for alfalfa. The quantity absolutely necessary will usually range between 1½ and 2 tons per acre; more will usually be beneficial. There are a number of different forms of lime which will serve the purpose. On the heavier soils freshly slaked lime, commercial hydrated lime or fine-ground quicklime will best meet requirements, since these forms of lime will both improve the mechanical condition and correct acidity. On the lighter soils, and especially if deficient in organic matter, air-slaked lime or fine-ground limestone may be preferable. The so-called agricultural limes, or waste lime, slaked in heaps at kilns will meet the requirements in most cases.

Manures or Fertilizers.

Manure. — While manure helps to give the soils the desired texture, and increases the proportion of humus, which may be beneficial, it usually carries weed seeds, and if applied shortly before seeding increases the difficulty of getting a good catch. The free use of manure will, moreover, be likely to increase the competition of grasses with the alfalfa, enabling these in a measure to gradually crowd the latter out. The application of manure in preparation for alfalfa is not recommended by the writer. On the other hand, a free use of manure for crops which precede alfalfa is desirable, especially on the lighter and poorer soils.

Potash. — Alfalfa, in common with clovers and other legumes, does well only when there is a liberal supply of potash in available forms in the soil. Potash fertilizers should be freely used in most cases in preparing for this crop. Potash in the form of sulphate, in the writer's experiments, appears much superior to potash applied in the form of muriate.[1]

Phosphoric Acid. — Although usually relatively less deficient in our soils as compared with the needs of alfalfa than lime and potash, it should be applied in some form, and among the different materials available basic slag meal seems usually to prove best, no doubt because it contains a large proportion of lime.

Nitrogen. — A large amount of nitrogen in the soil is not essential; from some points of view it is undesirable. To give the crop a good start, a fair amount of this element in available form in the soil is essential, but beyond that it is unnecessary and even harmful, — unnecessary because the alfalfa can draw nitrogen from the air, and harmful because it favors the grasses which may drive the alfalfa out.

VARIETIES.

There are a very large number of varieties of alfalfa now known. Many which may prove valuable have recently been introduced from Siberia by the South Dakota Experiment Station, but these are as yet insufficiently tested. There are but three kinds which deserve attention, known respectively as the common, the Grimm and the variegated.

Common Alfalfa. — This appears to be simply an unnamed strain. If from northern-grown seed, especially seed descended from generations of alfalfa grown in the north, it is fairly hardy and satisfactory.

Grimm. — A specially selected strain which originated in Minnesota; noted for hardiness and productiveness. It took its name from the farmer said to have been one of the most prominent in calling attention to the variety and promoting its dissemination. Comparative trials at this station and in many parts of the northern United States have indicated this variety to be superior in hardiness and in productive capacity to the common.[1]

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[1] See page 157.

Variegated Alfalfa. — This is said to be a cross between common alfalfa and yellow lucerne, a forage crop which is closely related to alfalfa. The flowers vary in color from yellow to greenish purple. This variety is said to be more hardy than ordinary alfalfa and adapted to poorer soils. Where either the common or the Grimm can be grown they are preferred to the variegated, which is characterized by decumbent growth, greater consequent tendency to lodge and lower feeding value. This variety has not been tested in the Massachusetts Experiment Station.

OBSTACLES TO SUCCESS.

Diseases. — Relatively few diseases have proved troublesome in Massachusetts. The only important one is leaf spot, which is most injurious on newly sown areas. The spots, which usually appear first on the lower leaves of the plant, are yellow to dark reddish brown in color. Sometimes the lower leaves only are affected, in which case not much damage will be done, but in cases of bad infection, and under favorable weather conditions (hot, humid air and frequent showers), the trouble may spread rapidly; all the leaves turn yellow and gradually fall. In such cases the disease if unchecked greatly enfeebles the plants, and weeds, grasses or clovers tend to displace the alfalfa. No preventive treatment is known, but the disease can usually be checked and healthy growth reëstablished by cutting, and whether the alfalfa be young or old it should be promptly cut if the disease appears to be serious and rapidly spreading toward the upper leaves. If the field is newly sown and the crop only a few inches high the cutting should not be too close, and what is cut may be allowed to lie where it falls. If the new growth is not healthy the field should be recut. In the case of an established field the forage may be either made into hay or fed green.

Dodder. — This is a parasite characterized by abundant development of thread-like reddish-yellow stems, attached to the stems of the alfalfa and bearing inconspicuous flowers of the same color. This parasite tends to spread rapidly; it renders the crop unpalatable. If noticed in the field it is best to cut the crop and burn it, plow the field and not put it into alfalfa again for a considerable number of years. Alfalfa dodder is not yet general in this State, and most energetic measures should be taken to exterminate it where it appears. If it shows in a field it is safe to conclude the seed of the dodder was mixed with the alfalfa seed. It is so fine it usually escapes detection by the average buyer. Dealers should be asked to guarantee alfalfa seed free from dodder. In cases of doubt samples of seed should be sent to the experiment station for examination.

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[1] See page 156.

Weeds. — Annual weeds will give but little trouble, provided such methods of seeding as are later recommended are followed. Especially is this true if the thorough preparatory tillage recommended when the seed is to be sown in late summer is followed. In the case of spring seeding, either with or without a nurse crop, annual weeds may compete with the alfalfa for water and food. If the growth is thick and rank the weeds may be clipped with a mowing machine set about 3 inches high. It is a mistake to sow alfalfa in fields heavily infested with the roots or seeds of perennial weeds. Especially is this true of witch grass, the competition of which alfalfa is wholly unable to withstand.

Grasses and Clovers. — In our better soils, and with our humid climate, some of the grasses and clovers, particularly Kentucky blue grass and white clover, tend to come in and gradually to crowd out the alfalfa. The tendency in this direction is increased by the use of barnyard or stable manures which, besides supplying large amounts of nitrogen (highly favorable to the growth of grasses), often carry their seeds as well as those of clover. It cannot be regarded as good practice to top-dress a well established field of alfalfa with manure of any kind. So doing, besides being objectionable from the points of view already stated, must be regarded as wasteful of nitrogen, the most costly plant-food element, since the alfalfa if well established is able to take this element so largely from the air.

It is possible, by the use of a harrow at the proper season, to in a measure check the coming in of grasses and clovers. These are more shallow rooted than alfalfa and may, therefore, be uprooted without much injuring the latter. A spring-tooth harrow properly set is the most effective type, and a special form of tooth has been designed for this particular use. This implement is advertised as the alfalfa harrow. Its use is most effective when the soil is relatively dry, and immediately after cutting either the first or the second crop will usually prove the best time for the operation.

Winterkilling. — Any one of the following causes may, under unfavorable conditions, destroy alfalfa: —

1. Heaving, which is most serious on the heavy soils. Tendency to this is much reduced by allowing a relatively heavy growth to remain in the field for winter protection. Perfect underdrainage, natural or artificial, of course lessens the tendency to heave, which is greater in proportion as the water content of the soil increases.[1]
2. Formation of ice on the surface. This is something which, under extreme weather conditions, may affect any field, but the tendency to this injury is comparatively small in fields where the slopes are such as to rapidly carry off surface water.
3. The presence of free acid in the soil, for this weakens the plant, rendering it susceptible to unfavorable conditions of any kind. The remedy is of course the application of lime.
4. Insufficient winter protection, due to too late cutting or excessive or overlate pasturing.

RECENT EXPERIMENTAL WORK WITH ALFALFA AT THIS STATION.

The more important of the recent experiments with alfalfa in this station have been as follows: —

1. Comparison of Grimm with the common alfalfa.
2. Comparison of high-grade sulphate with muriate as a source of potash.

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[1] Much alfalfa was killed during the year of 1913-14. The cause is not surely known; but it seems possible it was due in a measure to the large amount of water in the soil, owing to heavy fall and early winter rains (see p. 170).

3. Comparison of different methods of seeding.
4. A test of a commercial culture for inoculation.

In addition, we have had under constant observation a number of plots of different ages on which observations as to the gradual displacement of the alfalfa by grasses and clovers have been made.

1. *Grimm compared with Common Alfalfa.*

For a number of years it has been our object to make careful comparisons of the Grimm alfalfa with the common variety from northern-grown seed. Our first trials were begun in 1909, but although we obtained what we supposed to be Grimm seed of the very best quality from a grower recommended by the Minnesota Experiment Station, and believed to be absolutely reliable, our first experiments were a failure. There were no essential differences either in the appearance or the yield, and the party who furnished the seed later wrote us that a mistake had been made, that the seed sent as Grimm was not true to name. He supplied us, without charge, with seed of the genuine Grimm. This was sown after very careful preparation of the soil on a field where alfalfa had been previously grown in the late summer of 1911.

The land used in this experiment comprised two plots. Both have received annually for the past twenty-three years an application at the rate of 600 pounds per acre of fine-ground bone meal. One of the two plots has in addition annually received a liberal application of muriate of potash, for the last thirteen years at the rate of 250 pounds per acre; the other plot has annually received the same amount of actual potash, but in the form of high-grade sulphate, and for the last thirteen years at the rate of 250 pounds to the acre. Under both systems of manuring the Grimm alfalfa has given yields considerably larger than those obtained from the common. The results both for 1912 and 1913 are shown in the following table: —

Comparison of Varieties of Alfalfa and Source of Potash.

	Muriate of Potash.		High-grade Sulphate of Potash.	
	Grimm (Tons per Acre).	Common (Tons per Acre).	Grimm (Tons per Acre).	Common (Tons per Acre).
1912.				
1st cut,	2.122	1.56950	2.21875	1.98225
2d cut,	.465	.29075	.76925	.59150
3d cut,	.750	.63950	.94675	.82225
Totals,	3.337	2.49975	3.93475	3.39600
1913.				
1st cut,	3.08500	2.61600	2.94650	2.66250
2d cut,	.63935	.36045	1.00590	.71000
3d cut,	.40685	.29650	.57395	.50295
Totals,	4.13120	3.27295	4.52635	3.87545

The area of the plots used in these experiments is one-eighth acre each. The averages of both plots for the two years are: for the common alfalfa, 3.261 tons per acre; for Grimm alfalfa, 3.982 tons per acre, — a difference of about 22 per cent., greater yield in favor of the Grimm. In 1912 the yield of the Grimm alfalfa was 23 per cent. greater than that of the common. In 1913 both varieties yielded larger crops than in 1912, the yield of the Grimm being 21 per cent. greater than that of the common. The superiority of the Grimm as compared with the common is shown to have been no greater in the second year than the first. There is, therefore, no indication to date that the Grimm will prove more permanent than the other.

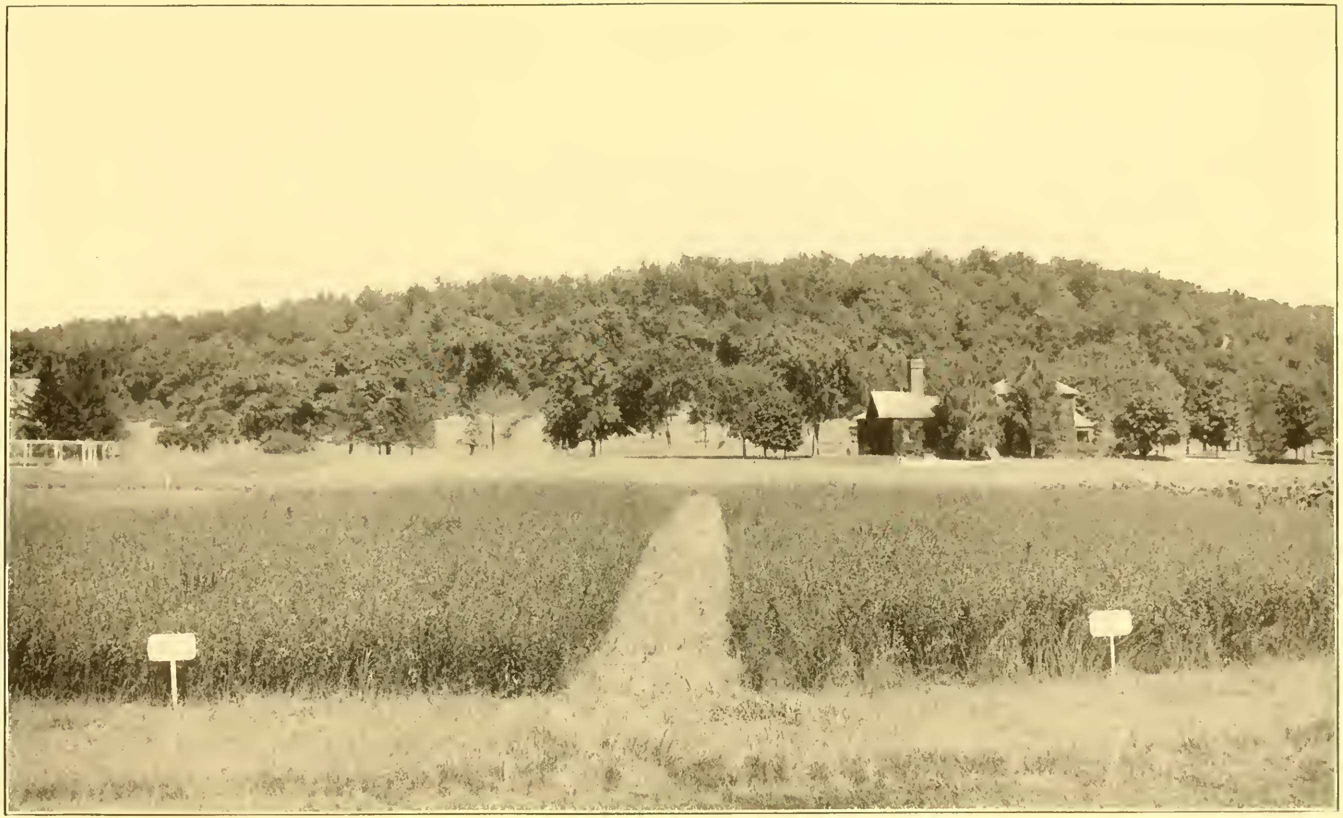
2. *Comparison of Potash Salts for Alfalfa.*

In one of the fields (Field B) of the experiment station grounds, the soil of which is a medium loam with compact and moderately clayey subsoil, alternate plots of one-eighth acre each have been continuously fertilized respectively with muriate and high-grade sulphate of potash in equal amounts for the past twenty-one years. These salts have been applied since 1900 at the rate of 250 pounds per acre each. Throughout the entire period (twenty-one years) these plots have each had an annual application of fine-ground bone meal at the rate of 600 pounds per acre. Throughout this entire period no manure has been applied to the land, and no other fertilizer of any kind with the exception of lime. Hydrated lime at the rate of 2 tons to the acre was applied broadcast upon the rough furrow in April, 1910, and deeply worked in by the use of the disk harrow.

Two plots in this field were sown to common alfalfa on Aug. 2, 1910. The seed did not germinate well, and the growth being too thin the plots were plowed July 12 and reseeded Aug. 5, 1911. One-half of each plot was sown to Grimm alfalfa and one-half to the common northern-grown seed. The yields on the two plots are shown in the table, page 157. It will be noticed that in every case the yield obtained on the sulphate of potash has been materially greater than that obtained on the muriate. The average rates of yield per acre for the two years on the two potash salts have been as follows: —

	Muriate of Potash (Tons per Acre).	Sulphate of Potash (Tons per Acre).
Grimm alfalfa, ...	3.734	4.231
Common alfalfa, ...	2.886	3.636

Whenever the crop is in active growth (and this has been true almost ever since the little seedlings appeared above the surface) there is a striking difference in the shade of green of the foliage on the two potash salts. The leaves on the sulphate of potash plots are of a much darker shade, which would be characterized as dark green. Those on the muriate of potash plots are much lighter. The shade would be characterized as yellowish or pea green. A similar difference in shade of foliage has been noticed in the case of other plants when grown on these potash salts. It is believed that this indicates a difference in character or number of the chlorophyl bodies of the two types of plants, — a difference which we have not, however, been able to demonstrate by scientific tests, but which apparently gives the chlorophyl bodies of the darker green plants a higher degree of functional activity.



Bone and muriate. Bone and sulphate.

3. *Spring and Summer Seeding compared.*

In the spring of 1910 a small area of silt loam soil, underlaid by gravel at the depth of 4 or 5 feet, was selected for the purpose of comparing the results of seeding in early spring with a nurse crop with the results of seeding in summer after bare fallow with sufficiently frequent harrowing to keep down weeds. The soil in question had been used during a number of years for a variety of crops including potatoes, corn and a test of varieties of alfalfa. Previous crops had been raised on fertilizers. No manure had been applied for many years. The soil contained a great many seeds of annual weeds, but it was not infested with the roots of perennial weeds. The entire field was limed on May 19 at the rate of $1\frac{1}{2}$ tons agricultural lime. On one-half of the field fertilizers at the following rates per acre were applied and harrowed in: —

	Pounds.
Basic slag meal,	1,500
High-grade sulphate of potash,	350
Nitrate of soda,	125

The spring sowing was made on May 19, with oats at the rate of 1 bushel per acre as a nurse crop. Fertilizers were applied to the other half on July 1, and the summer sowing was made on August 1.

From the spring-sown plot a fair crop of oats (somewhat mixed with weeds) was harvested in July, and in addition from this plot on September 21 was harvested a crop of alfalfa hay at the rate of 1.41 tons per acre. The yields from the two plots in the following year were as follows: —

Spring-sown alfalfa at the rate of 3.44 tons per acre.

Summer-sown alfalfa at the rate of 3.34 tons per acre.

From the statements so far made the conclusion must clearly be that the spring sowing had distinct advantages over summer sowing. We have first to its credit a fair crop of oat hay and a moderate crop of alfalfa the season of sowing; and second, the yield the following year was slightly greater than on the summer-sown alfalfa. There is, however, one point connected with the results distinctly unfavorable to the spring sowing, viz., the proportion of weeds in the product was much greater than in the crop from the summer sowing. The weeds were not separated from the alfalfa the first year, and during the second year only from the second cutting. The method followed was this: just previous to the second cutting, one square yard in each plot, which seemed as a result of careful examination to be fairly representative in both cases, was selected, and the entire product cut and separated into three classes, viz., alfalfa, grass and clover, and weeds. The results reduced to a percentage basis are shown in the following table: —

	Spring-sown Alfalfa (Per Cent.).	Summer-sown Alfalfa (Per Cent.).
Total weight,	100	100.0
Alfalfa,	65	86.6
Grass and clover,	15	1.6
Weeds,	20	11.6

4. *Inoculation.*

Two experiments in inoculation by the use of a commercial culture have been tried. The first was upon land fertilized annually for a long series of years with bone meal at the rate of 600 pounds, and muriate of potash at the rate of 200 pounds, per acre (Field D). The land had been used for a considerable variety of crops. No alfalfa had previously been grown on it.

The soil is a medium loam with a compact subsoil containing considerable clay. The culture employed was Farmogerm [1] and it was used, in accordance with directions, for the treatment of the seed before sowing. In preparation for the crop the soil received an application of lime applied to the rough furrow (and deeply worked in) at the rate of 3,500 pounds per acre. The grade of lime used was a so-called agricultural lime containing some hydrate, but mostly in the form of carbonate. The land also received a mixture of fertilizers at the following rates per acre: —

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[1] Farmogerm is made by the Earp-Thomas Farmogerm Company, Bloomfield, N. J. There are now numerous other commercial cultures on the market, and numerous colleges and experiment stations (this one among them) are now furnishing cultures for all legumes at cost to citizens of their respective States. No effort to compare the different cultures has been made in this station.

	Pounds.
Basic slag meal,	1,500
Muriate of potash,	500

This was deeply harrowed in. In addition, just previous to the last harrowing, a mixture of equal parts of nitrate of soda and fine-ground bone was applied at the rate of 500 pounds per acre.

The treatment of the soil brought it into a condition believed to have been highly favorable to bacterial activity; and the preparatory tillage had been such that it was moderately compact below, with the surface in fine mechanical condition and mellow. The seed was sown July 29. It germinated well and the ground was well covered, the crop being some 10 inches or more in height before cold weather set in.

The second experiment was upon a somewhat lighter soil (North Field) which would be characterized as a silt loam, underlaid with gravel of moderately open texture. This land had been annually manured for a considerable number of years with well-preserved manure from dairy cows. The rate of application had been moderately heavy. It had been used for a variety of forage crops in rotation, but no alfalfa had been grown upon it.

The preparation of the land and the general treatment were very similar to those in the other experiment. Lime was applied at the rate of 4,000 pounds per acre, basic slag meal at the rate of 600 pounds, and muriate of potash at the rate of 800 pounds per acre, and these were deeply incorporated with the soil by the use of the disk harrow. Just before seeding, a mixture of nitrate of soda and fine-ground bone meal in equal parts was applied at the rate of 400 pounds per acre. The seed was sown July 27, and as in the other field germination was perfect, and the ground well covered with abundant growth for protection during the first winter.

The seed used in both experiments was of two kinds: Montana-grown common alfalfa, and a variety which had been purchased under the name Grimm but which was later found not to have been true to name. It was, however, like the other, northern-grown seed; and the crops from the two kinds of seed showed no appreciable differences. The rates of yield are shown in the following table: —

	Field D.			North Field.		
	Inoculated (Tons per Acre).	Uninoculated (Tons per Acre).	Gain per Acre.	Inoculated (Tons per Acre).	Uninoculated (Tons per Acre).	Gain per Acre.
1910.						
1st cut,	2.33	1.97	.355	2.70	2.44	.257
2d cut,	1.02	.88	.140	1.63	1.54	.090
3d cut,	1.43	.98	.450	1.41	1.39	.020
Totals,	4.78	3.83	.945	5.74	5.37	.367

It will be noted that in both experiments there was considerable gain due, in so far as can be judged, to the use of the culture. An examination of the roots at a number of different points in the early spring of 1910 showed, however, that there were nodules on the uninoculated as well as on the other, and in both cases by the end of the season there was no difference which could be detected by close observation in the appearance of the inoculated and uninoculated plots. In 1911 the growth of the uninoculated was fully equal to that of the inoculated, and the weights were not separately taken. The value of the increase in the yield the first year, supposedly due to the inoculation, was, however, much greater than the cost of the culture ($2 for an acre) and the labor entailed in using it. The conclusion appears, therefore, to be justified that when alfalfa is put upon land on which the crop has never been grown the use of a commercial culture is likely to be profitable.

The rates of yield per acre on these fields in succeeding years are of interest in this connection. They show conclusively that on suitable soils rightly managed alfalfa is a valuable crop. The yields are shown in the following table: —

	Field D (Tons per Acre).	North Field (Tons per Acre).
1911,	2.72	2.80
1912,	2.99	3.58
1913,	3.89	4.97

The manurial treatment previous to the introduction of alfalfa in these fields, and the kinds and amounts of materials applied in preparation for the crop, have been given. Subsequent fertilizer treatment has been as follows: —

Field D. — From 1910 to 1912, inclusive, this was annually top-dressed with bone meal at the rate of 600 pounds, and muriate of potash at the rate of 200 pounds, per acre; and in 1913 the rate of top-dressing was basic slag meal 1,000 pounds, muriate of potash 200 pounds, per acre.

North Field. — This field received no top-dressing in either 1910 or 1911, but in 1912 and 1913 it was top-dressed with basic slag meal at the rate of 1,000 pounds, and sulphate of potash at the rate of 100 pounds, per acre.

In both fields the alfalfa is now considerably mixed with grasses, principally Kentucky blue grass and white clover. The yield, however, on both is still very large, and as both Kentucky blue grass and white clover rank exceptionally high in nutritive value the quality of the hay, though not pure alfalfa, is still much above the average in feeding value. An effort has been made to diminish the proportion of grass and check its spread in the North Field by thorough disking. This operation was carried out in the summer of 1912, immediately after the harvesting of the second crop. The result was a very material improvement.

Co-operative Experiments with Alfalfa

In Part I. of the twenty-third annual report the plans for the co-operative experiments now to be discussed were fully reported. These experiments were 33 in number. They were quite evenly distributed throughout the State, and were located on farms belonging to men especially recommended as well fitted for such work. The experiment station furnished the best obtainable seed. The soil was thoroughly prepared, the seed was inoculated with Farmogerm[1] and sown in the late summer of 1910. Three reports have been made by the farmers co-operating in this work.

The first of these reports was published in Part II. of the twenty-fourth annual report. This had reference to the conditions about the middle of May in 1911. Twenty-nine written reports only were received. The results may be classified as follows: successful experiments, 13; partially successful, 9; failures, 7.

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[1] See page 160.

Two other reports direct from the farmers have since been received: the first of these, made during the winter of 1912–13; the second, during the winter of 1913–14. On each occasion there was a diminished number of farmers responding, indicating, no doubt, failure on the part of most of those who did not report. The number of growers reporting in the winter of 1912–13 was 24. Of these, 6 were entirely successful, 8 partially successful and 10 had experienced failure.

At the time of the last report, in the winter of 1913–14, only 9 growers responded. Of these, 5 were successful, 1 partially successful and 3 had experienced failure.

The results obtained might be considered discouraging but for the fact that the causes of failure in most cases would seem to be avoidable. These causes, in the order of their importance, may be classified as follows: —

1. *Winterkilling.* — This appears to have been due in most cases to poor drainage or to too flat a surface, permitting standing water and ice. In some cases winterkilling seemed to be a consequence either of the fact that the seed was sown too late, or that the weather immediately following sowing was so dry that the crop did not get a good start. As a consequence of either of these conditions the first winter found the crop with insufficient growth for protection.

In other cases winterkilling was a consequence, also, of insufficient winter protection, but this was due either to the fact that the alfalfa was pastured too late in the fall or that the last cutting was made too late.

2. *Weeds and Grasses have crowded the Alfalfa out.* — This has occurred mainly on fields which either did not get a good start in the beginning, owing to imperfect germination of the seed, or on fields which were partially winterkilled, thus giving weeds and grasses opportunity to come in.

In some cases, however, the competition both of weeds and grasses with the crop has been accentuated by the use of manure as a top-dressing.

Among all the different weeds and grasses mentioned as crowding out alfalfa, witch grass is the one most frequently mentioned. It is perfectly clear that sowing alfalfa in land infested with witch grass is highly unwise.

Yield obtained. — The range of yields in the successful experiments as reported by the growers (in part estimated) is from 1 to 6 tons per acre. This wide variation reflects the extreme differences in character of soil as regards physical characteristics and fertility, and also, no doubt to some extent, the difference in thoroughness in the work of the different farmers concerned. The average yield per acre of the 7 growers who reported definitely is 3.2 tons.

The Dates of Cutting. — There has been considerable diversity of practice, in spite of the fact that very definite advice was given, in the dates of cutting. The range has been about as follows: the first cutting from June 17 to June 28; the second, July 20 to August 20; the third, August 25 to September 25.

The Opinions of Growers. — The following is a list of the farmers who are co-operating in this work and a brief statement of their opinions as to the value of this crop for the section of the State in which they live: —

C. M. CUDWORTH (*Cummington*). — Consider it a profitable crop if clover and timothy can be kept out.

JOHN H. BARTLETT (*Nantucket*). — I think it is a valuable crop to raise. I am going to put in more this season.

LOVETT BROTHERS (*Oxford*). — Have reseeded. New stand gives promise of a good crop.

C. W. PRESCOTT (*Concord*). — The crop is holding its own and doing well considering that no plant food has been applied since planting. One-half acre seeded to Grimm has been a wonder.

EDWARD KIRKHAM (*Holliston*). — Crop has gradually died out. Shall not try it again on my heavy soil unless I do some tile draining.

LYMAN P. THOMAS (*Rock*). — Crop winterkilled because of the mistake made in pasturing too late.

CHARLES L. CLAY (*North Dana*). — Still believe it to be a profitable crop if witch grass can be kept out.

PAUL CUNNINGHAM (*Bolton*). — Crop was killed out by drought of 1911.

H. A. PARSONS (*North Amherst*). — Results indicate crop to be valuable. Seeded 1⁹⁄₁₀ acres more.

CYRUS S. BARDWELL (*Shelburne*). — Do not believe the crop is suited to this vicinity.

G. B. TROWBRIDGE (*South Weymouth*). — The dry weather has a bad effect upon alfalfa; at least it seemed to kill most of mine after the first crop was cut.

J. B. Sawyer (*Bradford*). — Crop suffered because of the severe drought in 1913.

Howard W. Foster (*Lowell*, R. F. D. No. 1). — Condition of the crop compared with a year ago is much better.

John L. Smith & Son (*Barre*). — If it were not for witch grass should sow the rest of the field.

H. K. Herrick (*Blandford*). — Results obtained are encouraging. Shall try more.

Selection of Seed.

The experiments described in earlier pages indicate that the Grimm [1] alfalfa is superior to the common, but the latter has given satisfactory results in many cases. Whatever the variety, it is important that northern-grown seed be selected for New England use; and not only that the seed purchased for sowing shall have been grown in the north, but it should be descended from as many generations as possible of northern-grown alfalfa. It will be wise, as already pointed out, to purchase only on guarantee that the seed is free from admixture with the seed of dodder.[2] Where this parasite becomes established success with alfalfa becomes impossible.

Time and Method of Seeding.

Alfalfa may be sown with success either in early spring with a nurse crop or late in summer with corn or alone. Sowing alone in late summer is attended with less risk than any other method.

Spring Sowing. — Alfalfa sown in spring will usually start well, but in order to keep down the annual weeds which are almost sure to be abundant in our better soils it is essential to put in a nurse crop; and at the season when this is cut the weather is frequently so hot and dry that the young alfalfa is seriously injured. When seeding in spring it is recommended that the quantity of alfalfa seed should be about 25 to 30 pounds per acre. Either oats or barley will serve best as a nurse crop, and about 1 bushel of either will be sufficient.

Seeding in Corn. — In some cases seeding to alfalfa in the standing corn according to the method of seeding to grass, which is so commonly followed in the Connecticut valley has given successful results. This method, however, can be expected to succeed only when conditions are highly favorable. The soil must be one of fine texture, in perfect tilth, and naturally retentive of moisture. The corn field must be free from weeds, the corn must not be over thick, nor the growth excessively rank. If either of the last-named conditions exists the alfalfa will not make sufficient growth to go into the winter with adequate protection. If the corn is to be cut for the silo the alfalfa will be more likely to succeed than in field corn, for during the interval between the cutting of ensilage corn and cold weather it may make considerable growth. The best date for seeding in this manner is usually about the end of July. Showery weather should be selected if possible, and the quantity of seed should not be less than 30 pounds per acre.

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[1] See page 156.

[2] See page 153.

Summer Seeding alone. — This method of seeding has given more uniformly successful results than any other which has been tried in the station or upon the college grounds; indeed, with proper preparation it has never failed. The following is a brief outline of the most successful practice: —

1. Plow the previous autumn, or in spring as early as the ground can be worked.
2. Apply a heavy dressing of lime to the rough furrow either in fall or early spring and disk in at once.
3. As early in the spring as weed seeds begin to germinate apply the following mixture per acre: basic slag meal, 1,500 pounds; high-grade sulphate of potash, 400 to 500 pounds; and disk it in.
4. Between the date of the last operation and the date of sowing the seed (which should not be later than the last of July) harrow about once in ten or twelve days.
5. When ready to sow the seed apply per acre nitrate of soda, 100 pounds, basic slag meal, 300 pounds, mixing them and harrowing in lightly.
6. Sow 25 to 30 pounds of seed per acre, inoculating it if alfalfa has not been successfully grown on the land before, and cover as you would grass seed.
7. Inoculation may be effected either by the use of a com-

mercial culture, a culture which will be furnished by the college, or the incorporation of soil from a successful alfalfa field with the soil of the field to be sown. Inoculation of the seed is usually least expensive and fully as successful as the use of soil, but if the latter method is adopted sow 300 or 400 pounds per acre. It should be spread (in cloudy weather if possible) and at once harrowed into the soil. Cultures are most effective when fresh. They gradually lose vitality on keeping, and in ordering, whether from a commercial house or the college, the date when the culture will be used should be specified.

8. However luxuriant and abundant the growth following summer sowing, whether in corn or alone, it will not be advisable in the severe climate of New England to cut or pasture the crop. Even if the growth be a foot to a foot and a half in height it is worth more left in the field, and will not interfere with the development of the crop or the harvesting thereof the following season.

Harvesting Alfalfa.

Whatever the stage of development alfalfa should be harvested as soon as the buds or suckers which start near the base of the plant are well developed. This will usually be when the alfalfa is in early bloom. If allowed to stand much beyond the period of early bloom the plants start slowly after being cut, and the total yield of the season will be relatively small. In every case, however, before cutting examine the stem close to the ground to determine whether the basal buds are starting to grow. Whenever the cutting of the crop is too long delayed the result is a decrease in the total yield of the season. The last cutting should never be so late that the crop will not make growth sufficient for winter protection, and experience leads to the conclusion that in this climate this should be at least some 6 to 8 inches in height.

After cutting, alfalfa should be allowed to lie, with possibly one turning, until it is wilted. It should then be put into windrows which, if the weather is bad, may need to be turned once, and later into cocks where it should be allowed to remain until cured. Hay caps should be used if possible. Should the time required in curing it exceed about five days the cocks should be moved to avoid injury to the roots, and it is desirable, as in the case of clover (which is often similarly handled), to remove the caps and open or turn over the cocks on the morning of a good day, when it is judged to be sufficiently cured to be put in.

Top-dressing.

If the crop has been successfully inoculated, or if the nodules which have been referred to are abundant on the feeding rootlets of the alfalfa, it will not be necessary to top-dress with materials furnishing nitrogen, or at least if such materials are at all required (as may be the case upon soils which are naturally very poor and light) they should be used only in moderate quantities. If used freely, nitrogen stimulates the growth of grasses which, therefore, are all the more likely to crowd out the alfalfa. On the other hand, it is necessary in order to secure large crops that the mineral elements of plant food be accessible in abundance. If then the soil is not naturally richly stocked with phosphoric acid and potash these must be supplied, and the following mixture of materials is recommended annually per acre: basic slag meal, 800 to 1,200 pounds; high-grade sulphate of potash, 175 to 250 pounds; or low-grade sulphate of potash, 350 to 500 pounds. This mixture may be applied either in the autumn or in very early spring.

If basic slag meal is used as a source of phosphoric acid it is believed that a second application of lime will not be necessary, but if any other material is selected as the source of phosphoric acid a top-dressing with lime once in two or three years is likely to be beneficial.

Summary.

The following conclusions and advice appear to be warranted on the basis of the results obtained in the experimental work and practical experience of this institution: —

1. Alfalfa is superior to red and alsike clovers in holding the land longer, giving a somewhat greater average yield, and in fineness and palatability. The net energy value is about the same as that of good clover, but alfalfa hay is richer in protein and therefore better supplements corn silage, corn

fodder or corn and reduces the expenditure necessary for concentrated feeds.

2. Cultivation of alfalfa greatly improves the soil as a result, chiefly, of the deep penetration of its great tap roots and of the assimilation of atmospheric nitrogen which is left behind in large quantities in roots and stubble.

3. Alfalfa will thrive on almost all thoroughly drained soils, but the field should have considerable surface slope, and a soil rich in lime is best.

4. A heavy application of lime is in almost all cases necessary, usually from 1½ to 2½ tons at least.

5. On soils which are low in humus and relatively poor, one good application of manure plowed in is beneficial, but in general, fertilizers should be preferred to manure because less likely to bring in weeds, grasses and clovers.

6. The best source of potash for the crop is sulphate, and one of the best sources of phosphoric acid is basic slag meal.

7. The Grimm variety is superior.

8. Among the principal obstacles to success are leaf spot or rust, which can be prevented by cutting when it first appears; dodder, which can be avoided by care in the purchase of seed; the competition of weeds, grasses and clovers, which is reduced by avoiding manures or fertilizers rich in nitrogen; and winterkilling, which is due to poor drainage, formation of ice and insufficient growth for protection.[1]

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[1] Since this bulletin was written we have had opportunity to note the condition of alfalfa upon the station and college grounds in the spring of 1914. There is more winterkilling than for many years; and reports received from different correspondents indicate that the winter of 1913-14 has destroyed a large portion of the alfalfa in the State. A great deal appears to have been destroyed also in Connecticut.

The older seedings have in general suffered more than newly seeded areas, but in one case at least, reported by a large grower in Connecticut, the opposite was true.

The minimum temperature records were not exceptionally low, but from the middle of January until about the end of February the average temperature was low, and when lowest there was little snow protection. The principal known difference in conditions during the winter of 1913-14, and the winters of the recent years during which alfalfa has suffered little injury, was the higher proportion of water in the soil due to heavy autumn and early winter rains. It is the writer's belief that this was an important predisposing cause of injury. Alfalfa will endure extreme cold in relatively dry soils, but in soils containing a large proportion of water such temperatures subject its root system to most unfavorable conditions.

The Grimm variety has suffered far less than the common, even when the seed from which the latter was started was northern grown. In the light of existing conditions the writer's conviction is strengthened that our farmers will be wise not to depend too exclusively upon this crop. He would particularly urge that even although the seed be considerably higher in price, all farmers undertaking the growth of alfalfa should, for the present, plant Grimm variety, and as the demand for this seed is heavy and the price high he calls attention to the fact that there will be much temptation to substitute seed not true to name. The utmost care should be taken, therefore, to purchase only from parties known to be reliable.

9. The method of seeding attended with least risk is sowing alone in late summer after most careful preparatory tillage.

10. Inoculation of the seed is desirable when the crop is sown upon new land, and cultures used in accordance with directions are to be preferred to the use of soil in most cases.

11. In the co-operative experiments reported there is a large proportion of failures, but these appear to have been due to preventable causes, and the results are on the whole encouraging.

12. The crop should be cured with little exposure to direct sunshine and little handling to avoid loss of leaves.

13. It is a mistake to sow alfalfa in fields infested with witch grass.

14. The growth of weeds, grasses and clovers can be largely prevented by harrowing after the first or second cutting of any season when they are first present in noticeable proportion.

15. Annual top-dressing with slag meal and potash will in most cases be desirable.

COMPOSITION AND USE OF SOME OF THE NEW FERTILIZER MATERIALS; ALSO, FERTILIZING VALUE OF SOME LOCAL BY-PRODUCTS.

H. D. HASKINS.

In the large number of miscellaneous materials forwarded to the experiment station laboratory there occasionally appears a new fertilizing product or by-product of value to farmers living in the vicinity of the establishment which produces it. Oftentimes it may be a poorly balanced fertilizer, although if supplemented with chemicals or other fertilizing ingredients it may prove efficient. The large number of inquiries received regarding such products as sources of plant food would indicate the desirability of publishing a brief statement as to their use.

No. 1. Sheep Manure and Wool Waste.
No. 2. Wool Waste extracted of Grease (Sud Cake).

Analysis.

	No. 1.	No. 2.
Moisture,	4.99	44.80
Potassium oxide,	2.89	.37
Phosphoric acid,	.31	.03
Total nitrogen,	1.27	1.30
Water soluble nitrogen,	.51	.27
Active water insoluble nitrogen,	.30	.51
Inactive water insoluble nitrogen,	.46	.52
Approximate commercial value per ton,	$6 48	$4 00

Sheep Manure and Wool Waste (No. 1). — This manure, which is quite thoroughly dried, may be used at the rate of 4 to 5 tons per acre for corn; when used in seeding to grass, this application should be supplemented by 500 pounds of basic slag phosphate. Some of the commercial sheep manures, particularly those from wool-carding establishments, often carry large quantities of noxious weed seeds.

Wool Waste extracted of Grease (Sud Cake) (No. 2). — This product would be more suitable for corn and to fit land for seeding to permanent meadows than for potatoes or other hoed crops. It can be used to advantage on all soils deficient in organic matter and humus. Five tons per acre may be used to good advantage for corn or seeding to grass. In addition it would be well to use 150 pounds of muriate of potash and 500 pounds of basic slag phosphate.

No. 3. Fine-ground Foreign Whale Guano.
No. 4. Rockweed.
No. 5. Crude Unground Garbage Tankage.

Analysis.

	No. 3.	No. 4.	No. 5.
Moisture,	–	15.66	64.89
Potassium oxide,	None	1.81	.11
Phosphoric acid,	9.90	.23	.81
Total nitrogen,	8.16	.60	.78
Water soluble nitrogen,	2.08	.09	.15
Active water insoluble nitrogen,	3.43	.15	.10
Inactive water insoluble nitrogen,	2.65	.36	.53
Approximate commercial value per ton,	$37 00	$3 35	$1 80

Fine-ground Foreign Whale Guano (No. 3). — Whale guano is quite similar in composition to dry ground fish. Its nitrogen availability is probably about 67.50 per cent., while that of fish averages about 70 per cent. The whale guano carries quite a high percentage of fat (13.82 per cent.), which will probably prevent its nitrogen from becoming as quickly available as that in fish scrap.

Rockweed (No. 4). — Rockweed may be used broadcast at the rate of 5 to 6 tons per acre, and thoroughly worked into the soil by means of a disk harrow. The use of lime with this material will ordinarily be found advantageous, — from one-half to one ton per acre. The product carries but a small amount of phosphoric acid; the use, therefore, of 400 pounds of basic slag phosphate or acid phosphate per acre for crops such as corn and seeding to grass will usually be found both economical and effective. Rockweed may be used to advantage on any soil deficient in organic matter and humus. It is not a well-balanced fertilizer, however, and should ordinarily be supplemented by an application of some source of available phosphoric acid.

Crude Unground Garbage Tankage (*No. 5*). — Crude garbage tankage, undried and unground, is necessarily a coarse, slow-acting material; yet it has more than a local interest, as most of our cities having a population of 30,000 to 40,000 own municipal garbage-reduction plants, and a considerable tonnage of tankage is therefore annually produced. A considerable amount of this material is contracted for by the commercial fertilizer manufacturer who uses it as a conditioner in fertilizer mixtures after it has been dried and ground. In this condition it is, of course, worth much more as a fertilizer than in its crude state. Of late there has been considerable inquiry regarding the value of the product, and requests for analysis are not infrequent. In its natural state it may be worth cartage to farmers living in the vicinity of the plant. The product may be used like farm manures, — from 5 to 6 cords per acre would not be an excessive application. It should be thoroughly worked into the soil with a disk harrow, and ordinarily should be accompanied by an application of lime. From 400 to 600 pounds of basic slag phosphate and 100 to 150 pounds of muriate or high-grade sulfate of potash per acre should be used to supplement it.

No. 6. Calcined Phosphate.
No. 7. Calcium Cyanamid.
No. 8. Sewage Tankage.

Analysis.

	No. 6.	No. 7.	No. 8.
Moisture,	-	2.23	7.30
Potassium oxide,	.59	-	.03
Total phosphoric acid,	32.06	-	1.62
Available phosphoric acid,	26.32	-	-
Calcium oxide,	36.99	40.00	-
Iron and aluminum oxides,	6.66	-	-
Sodium oxide,	7.40	-	-
Total nitrogen,	None	14.33	5.26
Water soluble nitrogen,	None	12.99	.40
Active water insoluble nitrogen,	None	.41	2.38
Inactive water insoluble nitrogen,	None	.93	2.48
Approximate commercial value per ton,	$23 25	$54 45	$16 65

Calcined Phosphate (*No. 6*). — Calcined phosphate, as the name indicates, is a manufactured product, high calcination being a part of the process. It is represented to be made under the so-called Newberry-Fishburne process, which, briefly stated, is as follows: —

A 30 to 32 per cent. phosphate rock is mixed with 15 to 20 per cent. of an alkaline salt. The mixture is heated in rotary kilns to a high temperature. During the process most of the salt is volatilized. The resulting porous clinker is pulverized and ground to a fine condition suitable for a fertilizer. The product gives a mild alkaline reaction.

Unpublished results at the Ohio and Indiana Experiment stations indicate that this material furnished phosphoric acid in an available form. The writer has not heard of the product being generally quoted in the fertilizer trade, and its cost is therefore not known.

Calcium Cyanamid (*No. 7*). — Calcium cyanamid, now generally handled in the trade under the name cyanamid, although not a new product is but rarely used by the farmer except as a part of commercial mixed fertilizers in which it is now not infrequently used. It is said that most of it is now bought by the fertilizer manufacturers. In view, however, of the large number of inquiries received concerning its nature, a short description may not be out of place.

Cyanamid is made by combining atmospheric nitrogen with calcium carbide at a high temperature, electricity being used as the heating agency. Two forms of cyanamid are now offered to the trade in this country, both being of a dark slate color. One is a fine powder, the other granular. The chemical composition of the two products seems to be about the same. The granular cyanamid possesses some advantages over the powdered form. It would be less dusty and disagreeable to handle, and probably could be used in larger proportions in mixtures with organic ammoniates and acid phosphates without causing loss of ammonia or serious reversion of the phosphoric acid. The nitrogen in cyanamid is largely soluble in water and in availability ranks well with sulfate of ammonia; it is not in the form of ammonia, however, but rather of an amide compound which is easily broken up in contact with water and becomes readily available in the soil. The product may be used as a quick-acting nitrogen source. Cyanamid may have an advantage over sulfate of ammonia in that it will not leave an objectionable acid residue in the soil as does the latter product. The residue left by cyanamid is a lime product which sooner or later will have a beneficial sweetening effect upon the soil. It would probably not be good practice to use more than 100 to 150 pounds of the cyanamid to the ton if the fertilizer mixture is likely to remain unused for a number of months. The free lime in the cyanamid will gradually cause a reversion of the soluble phosphoric acid. In the preparation of home-mixtures, which contain nitrate of soda, tankage, dry ground fish, blood, as well as other organic ammoniates, with acid phosphate and potash salts, a small proportion of cyanamid will be wisely included, as it favors the improvement of the mechanical condition of the mixture. It will aid materially in preventing the lumping of the fertilizer as well as the loss of nitrogen from the nitrate of soda under the influence of freshly prepared acid phosphate. These advantages will more than compensate any loss in the solubility of the phosphoric acid in the acid phosphate due to the action of the free lime in the cyanamid. This is particularly true if the proportion of cyanamid to the acid phosphate is not greater than 1 to 8 or 10. Cyanamid should not be used in the same mixture with ammonium sulfate, as free ammonia will be liberated from the latter salt. It should prove a valuable source of quick-acting nitrogen for most crops, but is not recommended as a top dressing for grass. It will not be found injurious when applied unmixed at the rate of 200 pounds per acre as a source of part of the nitrogen for tobacco.

Sewage Tankage (No. 8). — Sewage tankage, as the name indicates, is a product recovered from sewage by means of the precipitation method. In the sample here reported the grease was extracted from the dried material, which was then ground to a good mechanical condition. The sample analyzed carried about 78 per cent. of organic matter. Products of this character vary greatly in composition, as two samples examined at this laboratory in 1912 showed only .32 per cent. nitrogen, the phosphoric acid running 6.67 per cent. and the potash .78 per cent. Such a product would be valued commercially at about $5.50 per ton.

It has not been found commercially profitable to extract the fat from sewage tankage. The unextracted material has a very slow action in the soil, and practical experience does not encourage its use.[1]

No. 9. Picker Dirt from Cotton Mill, Average of Three Analyses.
No. 10. Cocoa-shell Dust.
No. 11. Shoddy Dirt from Woolen Mill.

Analysis.

	No. 9.	No. 10.	No. 11.
Moisture,	6.95	11.09	4.95
Potassium oxide,	1.56	2.71	.68
Phosphoric acid,	.68	1.49	.20
Total nitrogen,	1.37	2.94	4.40
Water soluble nitrogen,	.24	1.04	.12
Active water insoluble nitrogen,	.27	.51	2.41
Inactive water insoluble nitrogen,	.95	1.39	1.87
Approximate commercial value per ton,	$5 50	$9 50	$11 00

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[1] See Monthly Bulletin, State Board of Health, Vol. 8, No. 12, December, 1913.

Picker Dirt from Cotton Mill (*No. 9*). — Picker dirt varies somewhat in composition; 19 analyses made at this laboratory show the nitrogen to vary from 1.55 to 1.60 per cent., the potash from .48 to 1.62 per cent., and the phosphoric acid from .08 to .68 per cent. The average commercial value on the basis of these analyses would be $3.75 per ton. The product would be slow in action when incorporated with the soil. Probably the most economical manner of using the material would be to add it at frequent intervals to the manurial matter in the manure pit; when used in this way it would retain a large amount of liquid manure and prove of value both as an absorbent and as a direct furnisher of plant food. It would not be a suitable material to use in the stable gutters on account of the dust, which would have a tendency to irritate the air passages and lungs of animals, and also because of the danger in carrying the germs of contagious diseases. A moderate application of lime should be used on the soil with this product, also about 400 pounds of basic slag or acid phosphate and 100 pounds of high-grade sulfate of potash per acre. The material will be found better adapted to corn and seeding to grass than to most other crops, and may be used at the rate of, three cords per acre. It should be plowed in.

Cocoa-shell Dust (*No. 10*). — Cocoa-shell dust carries considerably more plant food than do ground cocoa shells, testing nearly a per cent. higher in nitrogen and phosphoric acid. The material may be used at the rate of 1 ton per acre. It should be supplemented by an application of 100 pounds of muriate of potash and 300 pounds of basic slag phosphate or acid phosphate.

Shoddy Dirt from Woolen Mill (*No. 11*). — Shoddy dirt will be found to vary considerably in composition. It is not a well-balanced fertilizing material, as it carries too little potash and phosphoric acid in proportion to the nitrogen. It may be used at the rate of 3 tons per acre applied broadcast and thoroughly wheel-harrowed in. For corn and seeding to grass 800 pounds of lime, 500 pounds of basic slag or acid phosphate and 150 pounds of muriate of potash should also be used per acre. On poor soils 100 pounds of nitrate of soda may be used to advantage when seeding to grass.

No. 12. Lime Refuse from Manufacture of Lactic Acid.
No. 13. Lime Refuse from Bleachery Filter Bed.
No. 14. Lime Refuse from Tannery.

Analysis.

	No. 12.	No. 13.	No. 14.
Moisture,	46.00	16.87	35.93
Calcium oxide,	19.23	42.43	24.80
Magnesium oxide,	.44	1.30	3.10
Nitrogen,	.30	-	.42
Sulfuric acid (SO_3),	27.50	-	-
Carbonic acid (CO_2),	.98	34.00	4.44
Insoluble matter,	.68	-	16.37

Lime Refuse from Manufacture of Lactic Acid (*No. 12*). — Lime refuse from the manufacture of lactic acid would not be a fit material to use agriculturally until mixed with 200 or 300 pounds of limestone per ton of refuse. The raw product carries nearly one-half of one per cent. of free sulfuric acid, which would probably injure vegetation unless neutralized by the limestone. The value of the product would not be over $2 to $3 per ton at the farm. After receiving the application of limestone the product should be used the same as land plaster or gypsum, as most of the lime is present as sulfate.

Lime Refuse from Bleachery Filter Bed (*No. 13*). — This particular sample contained practically all of its lime in the form of carbonate. It gave only a slight reaction for chlorides. In ordinary practice it would be well to apply the material during late fall and allow it to remain exposed until spring, so that any injurious lime compounds that might be present would have a chance to oxidize before being mixed with the soil. It may be used in quantities up to 2 tons per acre on land in need of lime.

Lime Refuse from Tannery (*No. 14*). — Most of the lime in this sample was present as hydrated or slaked lime. The product carries nearly one-half of one per cent. of arsenic (As_2O_5). If the product be used in moderate quantities (2 tons per acre) this amount of arsenic would probably not prove injurious to vegetation. It might, however, have a deleterious effect upon the beneficial soil bacteria. The sample has been submitted to the college bacteriologist, Dr. Marshall, who will later make some studies to decide this point. The opinion was expressed by Dr. Marshall that this small percentage of arsenic would not prove harmful when used as above specified.

In general, it might be said that these various refuse lime products, including the product from acetylene gas plants, may be used to advantage locally when they can be had for the hauling or at a small cost. It is usually the safest way to make the application of these products in the fall or winter, so as to allow a chance for the oxidation of any injurious compounds that may be present.

COCOANUT MEAL.

J. B. LINDSEY.

The cocoanut is the fruit of the cocoa palm (*Cocus nucifera*), growing in Ceylon, India, West and East Africa, the Philippine Islands, Brazil and Australia. It is valuable for its shell (which furnishes fiber), its oil and its meat. The milk in the inner part of the nut gradually becomes thick as the cocoanut ripens, and forms the meat of the nut. According to Ollech,[1] a typical ripe nut was found to consist of 30.45 per cent. of fiber, 19.59 per cent. of shell, and 49.96 per cent. of meat, and to weigh 1,133 grams. The oil is removed by pressure or by extraction by cooking with water, frequently at the place of production. The meat is shipped in a dry condition to Europe under the name of Kopra. The dry, unextracted meat (8 per cent. water) contains from 36 to 67 per cent. of oil.

The extracted meat is ground and furnishes the cocoanut meal used in animal feeding. When in normal condition it is light red to brown in color, has a nutty smell and taste, and is well liked by all kinds of farm animals.

The lot experimented with was secured from the Edible Oils Company of New York, who imported it.

1. COMPOSITION OF COCOANUT MEAL.

	Our Sample.	Average German Analyses.	Gluten Feed used in Experiment for Comparison.
Water,	9.00	10.50	10.40
Ash,	5.89	6.20	3.78
Protein,	19.35	21.40	23.37
Fiber,	8.64	14.70	6.82
Extract matter,	48.00	38.70	52.75
Fat,	9.12	8.50	2.88
Total,	100.00	100.00	100.00

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[1] E. Pott, Handbuch d. Thierischen Ernährung, etc., Bd. III., p. 76.

Our particular sample contained rather less protein and fiber and more extract matter than the average of German samples. The latter, according to Kellner,[1] are sold on a guarantee of 18 per cent. protein and 12 per cent. fat. The gluten feed with which cocoanut meal is compared shows less ash and fat, rather more protein, and decidedly more starchy matter. The oil in the cocoanut meal very soon becomes rancid, and is converted largely into free fatty acids, giving a slightly unpleasant odor and taste.

2. Digestibility of Cocoanut Meal.

One experiment was conducted with two sheep, with the following results: —

	Our Sample.	Average German Analyses.	Gluten Feed for Comparison.
Dry matter,	–	80[2]	88
Ash,	64	–	88
Protein,	90	78	85
Fiber,	23	63	87
Extract matter,	87	83	90
Fat,	100+	97	81

Applying these coefficients to the analyses, we find the following amounts digestible in 2,000 pounds: —

	Cocoanut Meal (Our Sample).	Gluten Feed for Comparison.
Ash,	75.4	66.5
Protein,	347.6	397.2
Fiber,	40.4	118.6
Extract matter,	829.0	949.6
Fat,	187.4	46.6
Total,	1,479.8	1,578.5

It appears from the above results that the gluten feed furnishes about 100 pounds more digestible nutrients in 1 ton than the cocoanut meal. If, however, the fat in each case is converted into its starch equivalent in the usual way, we find the cocoanut meal furnishes 1,705 pounds of digestible matter and the gluten feed 1,634 pounds. The cocoanut meal contains 88.4 therms of net available energy and the sample of gluten feed 82.7 therms. In case of gluten feed, Kellner requires a reduction of 10 per cent., making the therms 74.4 as against 88.4 for the cocoanut meal. It seems doubtful, however, to the writer if this 10 per cent. reduction is allowable. It hardly seems probable on the basis of composition and digestibility that the cocoanut meal would have a much greater nutritive value than would the gluten feed.

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[1] Die Ernährung d. Landw. Nutzthiere, p. 359.

[2] Organic matter.

3. FEEDING EXPERIMENT WITH COCOANUT MEAL, 1911.

In order to test the relative efficiency of the cocoanut meal as compared with gluten feed as a component of a dairy ration, 10 cows were fed by the reversal method in periods of five weeks' duration. Hay and wheat bran constituted the basal ration to which were added definite amounts of either cocoanut meal or gluten feed.[1]

TABLE I. — *History of the Cows.*

NAME.	Breed.	Age (Years).	Last Calf dropped.	Served.	Milk Yield (Pounds), Beginning of Trial.
Samantha,	Jersey-Holstein,	7	Aug. 15, 1910	Dec. 17, 1910	25
Amy,	Pure Jersey,	3	Sept. 20, 1910	Mar. 1, 1911	17
Gladys,	Pure Jersey,	7	Sept. 15, 1910	Aug. 14, 1911	21
May Rio,	Pure Jersey,	7	Dec. 5, 1910	Apr. 12, 1911	20
Betty,	Grade Jersey,	6	Oct. 22, 1910	Dec. 22, 1910	28
Betty II.,	Grade Ayrshire,	3	Dec. 8, 1910	Jan. 26, 1911	31
Fancy II.,	Grade Jersey,	3	Aug. 16, 1910	Dec. 22, 1910	18
Cecile,	Pure Jersey,	5	Nov. 1, 1910	Feb. 8, 1911	28
Ida,	Pure Jersey,	3	Sept. 5, 1910	Feb. 11, 1911	15
Red III.,	Grade Jersey,	5	Oct. 8, 1910	Dec. 14, 1910	28

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[1] Cow Betty, being particularly thin, was given 1 pound of corn meal daily as a part of the basal ration in each half of the trial.

TABLE II. — *Duration of Trial, 1911.*

DATES.	Gluten Feed Ration.	Cocoanut Meal Ration.
January 6 through February 10, .	Samantha, Amy, Gladys, May Rio, Betty.	Ida, Fancy II., Betty II., Cecile, Red III.
March 11 through April 14, . .	Ida, Fancy II., Betty II., Cecile, Red III.	Samantha, Amy, Gladys, May Rio, Betty.

An unusually long time elapsed between the two halves of the trial (four weeks). This was due to the fact that several cows in the herd suffered a severe attack of scours, the cause of which could not be determined. It naturally interfered with the accuracy of the trial, although all of the cows were in good condition when the second half started, March 11. They had shrunk, however, rather more in yield than they would have had they not suffered the attack. Cows Amy, Betty II., Cecile and Betty were particularly affected.

Care and Feeding of Animals.

They were kept in roomy stalls, carded daily and turned into a protected barnyard for three to five hours each pleasant day. They were fed twice daily; the hay was given some time before milking in the afternoon and the grain just before milking, while in the morning the grain was given just before, and the hay just after, milking. Water was supplied constantly by aid of a self-watering device.

Character of Feeds.

The hay was largely Kentucky blue grass with considerable sweet vernal grass and some clover (early cut). During the last half of the trial the supply of this grade of hay became exhausted, and a mixture of timothy, red top and clover was substituted. It was of very good quality, but not as appetizing as the other variety. The animals refused some of the coarser parts and showed a tendency to shrink in milk. The bran was of the spring variety, and the gluten feed of good quality.

Weighing the Animals.

Each cow was weighed for three consecutive days at the beginning and end of each half of the trial, before the afternoon feeding.

Sampling Feeds and Milk.

The hay was sampled at the beginning and end of each half of the trial in the usual way, as described in other experiments of this character. The grains were sampled daily and the samples preserved in glass-stoppered bottles and brought to the laboratory at the end of each half of the trial for dry-matter determinations and complete analyses.

The milk of each cow was sampled daily for five consecutive days on the first, third and fifth week of each half of the trial. The usual method of sampling was followed.

TABLE III. — *Analysis of Feedstuffs.*

	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
Hay,	9.97	8.04	1.71	44.47	30.84	4.94
Bran,	11.97	16.10	1.36	55.99	9.23	5.33
Gluten feed,	10.28	23.39	2.88	52.82	6.83	3.79
Cocoanut meal,	6.49	20.05	15.07	44.98	8.43	5.06
Corn meal,	12.89	8.69	3.31	72.07	1.78	1.25

TABLE IV. — *Total Rations consumed by Each Cow (Pounds).*

Gluten Feed Ration.

	Hay.	Bran.	Gluten Feed.	Corn Meal.	Cocoanut Meal.
Samantha,	908	140	140	-	-
Amy,	625	105	140	-	-
Gladys,	695	105	140	-	-
May Rio,	695	105	105	-	-
Betty,	900	105	140	35	-
Ida,	689	105	105	-	-
Fancy II.,	522	100	100	-	-
Betty II.,	690	175	140	-	-
Cecile,	689	138	138	-	-
Red III.,	797	140	140	-	-
Totals for herd,	7,210	1,218	1,288	35	-

TABLE IV. — *Total Rations consumed by Each Cow (Pounds)* — Concluded.

Cocoanut Meal Ration.

	Hay.	Bran.	Gluten Feed.	Corn Meal.	Cocoanut Meal.
Samantha,	790	140	–	–	140
Amy,	514	99	–	–	133
Gladys,	624	105	–	–	140
May Rio,	672	105	–	–	105
Betty,	711	105	–	35	140
Ida,	764	105	–	–	105
Fancy II.,	481	105	–	–	105
Betty II.,	746	175	–	–	140
Cecile,	793	140	–	–	140
Red III.,	840	140	–	–	140
Totals for herd,	6,935	1,219	–	35	1,288

TABLE V. — *Average Daily Ration consumed per Cow (Pounds).*

CHARACTER OF RATION.	Hay.	Bran.	Gluten Feed.	Cocoanut Meal.	Corn Meal.
Gluten feed,	20.6	3.48	3.68	–	1[1]
Cocoanut meal,	19.8	3.48	–	3.68	1[1]

The cows averaged .8 of a pound of hay more daily while on the gluten feed ration. This may have been due to the presence of the extra oil in the cocoanut meal satisfying the appetites. The different animals received from 16 to 26 pounds of hay, from 3 to 5 pounds of bran and from 3 to 4 pounds of gluten feed or cocoanut meal daily.

TABLE VI. — *Digestible Organic Nutrients in Average Daily Rations (Pounds).*

CHARACTER OF RATION.	Protein.	Fiber.	Extract Matter.	Fat.	Total.[2]	Nutritive Ratio.
Gluten feed,	2.10	4.13	8.70	.32	15.95	1:6.5
Cocoanut meal,	1.92	4.00	8.12	.75	15.69	1:7.2

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[1] For cow Betty only; not included in figuring average digestible nutrients.

[2] Including fat × 2.2.

It would appear, on the basis of the above calculations, which were made by applying average digestion coefficients to average daily rations consumed, that the two herds received substantially like amounts of total digestible nutrients. The cocoanut meal ration contained rather more fat and somewhat less extract matter than the gluten feed ration.

Herd Gain or Loss in Live Weight (Pounds).

Character of Ration.	Loss.
Gluten feed,	8
Cocoanut meal,	79

The difference is not of great importance. During the gluten feed period the 10 cows showed a total loss of 8 pounds, and during the cocoanut meal period a loss of 79 pounds. Cows Cecile and Betty II. were milking their maximum while in the cocoanut meal period, which took some flesh from their bodies.

Total Yield of Milk Products (Pounds).

Gluten Feed Ration.

	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (Fat+⅙).
Samantha,	876.3	24.8	135.74	54.59	63.69
Amy,	608.8	17.4	91.81	35.55	41.48
Gladys,	731.8	20.9	112.99	44.93	52.42
May Rio,	741.8	21.2	111.72	43.84	51.15
Betty,	902.8	25.8	128.65	45.05	52.56
Ida,	447.8	12.8	75.95	32.60	38.03
Fancy II.,	537.9	15.4	74.93	27.33	31.89
Betty II.,	827.2	23.6	115.89	39.54	46.13
Cecile,	793.5	22.7	113.39	39.91	46.56
Red III.,	810.5	23.2	113.31	44.33	51.72
Totals for herd,	7,278.4	20.8[1]	1,074.38	407.67	475.63

[1] Average daily yield.

Total Yield of Milk Products (Pounds) — Concluded.

Cocoanut Meal Ration.

	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (Fat+1/6).
Samantha,	698.8	20.0	110.62	47.10	54.95
Amy,	482.8	13.8	73.63	31.29	36.51
Gladys,	579.6	16.6	86.59	35.76	41.72
May Rio,	592.3	17.0	91.63	38.14	44.50
Betty,	720.3	20.6	103.72	38.68	45.13
Ida,	525.3	15.0	90.40	40.97	47.80
Fancy II.,	583.5	16.7	82.86	32.56	37.99
Betty II.,	1,124.8	32.1	155.00	56.46	65.87
Cecile,	991.5	28.3	145.65	56.22	65.59
Red III.,	902.3	25.8	129.48	54.68	63.79
Totals for herd,	7,201.2	20.6[1]	1,069.58	431.86	503.85

The 10 cows produced substantially the same amounts of milk and milk solids on both rations. In the case of the total milk fat the difference is somewhat in favor of the cocoanut meal ration (nearly 6 per cent.). This may have been due to the influence of the oil in the cocoanut meal.

Adverse Influences.

1. The attack of scours between halves.

2. The feeding of a new lot of hay during the last two weeks of the trial. The hay, however, was fed to each of the 10 cows so that all were treated alike.

3. While like amounts of gluten feed and cocoanut meal were fed to each herd the cocoanut meal contained 6.49 per cent. of moisture, while the gluten feed contained 10.28 per cent. During the entire experiment, therefore, the cows received 50.2 pounds more dry matter (.14 pound daily) in the form of cocoanut meal than in the form of gluten feed.

Inasmuch, however, as the cows ate rather less hay while receiving the cocoanut meal, and as the total digestible nutrients fed were slightly in favor of the gluten feed ration, it is probable that the small excess of cocoanut meal was without influence on the results.

---

[1] Average daily yield.

General Conclusions.

1. Cocoanut meal is of the same general type of composition as gluten feed. It contains more fat, ash and fiber and noticeably less carbohydrate matter.

2. Cocoanut meal was found to contain about 100 pounds less digestible matter in a ton than the gluten feed. By converting the fat of the cocoanut meal into its starch equivalent, however, its nutritive value would be rather above the gluten feed. One hundred pounds of cocoanut meal contained 88.4 therms of net available energy as against 82.7 therms for the gluten feed. This is clearly due to the higher percentage of fat in the former.

3. Our feeding experiment with 10 cows shows substantially the same results in the amount of milk from the cocoanut meal and gluten feed ration; slightly more butter fat was secured on the former ration.

It is believed that the cocoanut meal is fully equal to the gluten feed in nutritive value, although it is doubtful if it exceeds it. German observers consider it particularly desirable for dairy animals in amounts of from 3 to 4 pounds daily per head, and it has been shown to somewhat increase the fat content of the milk. Fed in excess of the above it is held to make too hard a butter.

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